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THE RUSTS OF AUSTRALIA

(UREDINEAE).



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GALL-FUNGUS
DESTROYING GOLDEN WATTLE.

DEPARTMENT OF AGRICULTURE, VICTORIA.

THE RUSTS OF AUSTRALIA

THEIR STRUCTURE, NATURE, AND
CLASSIFICATION.

BY

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WITH 55 PLATES (INCLUDING 366 FIGURES).

Melbourne :

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PREFACE.

The Rusts are among the most widespread and destructive of our fungus parasites, and in order to mitigate the injury caused by them as much as possible, it is necessary to know their nature and mode of life.

The rust of wheat has naturally received a large share of attention on account of its influence upon one of our staple industries; but it is still only one of a number that require to be studied. Hence, at the several Rust in Wheat Conferences held in the different States, investigations were invariably recommended to be made "regarding all plants that are affected by rust in the different colonies," because it was felt that such a wide outlook was necessary even for understanding properly the history of a single species. The present work, then, which has been in hand for a number of years, aims at recording all rusts, as far as known in Australia at present, and this will prepare the way for a consideration of the best methods of preventing their appearance, or limiting their spread in the numerous commercial crops subject to their ravages.

The familiar saying that to know any subject well we must know the details of it, is very applicable in this case. The necessary details are given here to enable one to recognise the different forms the rusts assume, and the different stages through which they generally pass in order to complete their life-history. Besides, there is a special object in view in thus recording and describing the Rust-fungi of Australia, for this can afterwards be used as a basis in working out the life-history of those particular forms which attack our cultivated and economic plants, and often do considerable damage.

All the species known to occur in Australia are included, and when proved to be aliens, they are noted as introduced in the index. Every species of which specimens are available is also figured in its essential parts, so that there may be no doubt as to the form intended. In this I have been ably aided by my assistant, Mr. G. H. Robinson, who has supplied the numerous photomicrographs reproduced here, which give such a vivid representation of the peculiar and distinguishing characters of the spores. A number of drawings have likewise been executed by Mr. C. C. Brittlebank, who has had considerable experience in drawing from microscopic preparations.

The principal works consulted, or referred to, are given in the Bibliography at the end, and those wishing for fuller references, will find them in Klebahn's *Die wirtswechselnden Rostpilze* [The Heteroecious Rusts], 1904. This will give a good idea of what has already been done in the investigation of the rusts, but no one can fail to appreciate the work accomplished by that veteran mycologist, Dr. Cooke, in his

Handbook of Australian Fungi. When one considers that the material had to be sent such long distances, and often limited in quantity, as well as imperfectly preserved, it is surprising the number of rusts recorded, and the general accuracy of the descriptions. It is a matter within my personal experience, that in order to do justice to the rusts, it is necessary to have plenty of material and to have it fresh, and there is always a decided advantage in collecting your own specimens. The Australian rusts recorded in the *Handbook* published in 1892 were 72, and the number now has reached 161.

To all those who have contributed specimens, my best thanks are due. The late Mr. Luehmann, F.L.S., Government Botanist of Victoria, allowed me free access to the specimens in the National Herbarium and Mr. Bailey, F.L.S., the Government Botanist of Queensland, who has done so much in every division of botany, always willingly aided me with specimens or information; the Government Botanist of New South Wales, Mr. Maiden, F.L.S., as well as R. T. Baker, F.L.S., of the Technological Museum, and A. G. Hamilton also supplied me with any material required from the sister State, as well as Dr. Morrison, of Western Australia, and Mr. Rodway, F.L.S., of Tasmania. Messrs. Molineux and Quinn, of South Australia, have also contributed, and Mr. J. G. O. Tepper, F.L.S., has generously supplied me with numerous, and often type specimens from his extensive collection.

My colleague, Mr. French, F.L.S., Government Entomologist, and his assistant, Mr. C. French, junior, never lost an opportunity of securing specimens in their frequent collecting trips; and Messrs. Reader and Musson have added new species to the list. I have also to acknowledge the courtesy of the Director of the Royal Gardens, Kew, in supplying me with any specimens required for verification or illustration.

No one is more conscious than myself of how much yet remains to be done before the Rusts of Australia are thoroughly understood, but the present work will at least lighten the labours of those who desire to increase that knowledge, and by the combined efforts of various workers in this promising field, their true nature and life-history may be so revealed that the ravages due to them, in a congenial climate such as ours, may be reduced to a minimum.

Melbourne, March, 1906.

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PART FIRST.

GENERAL CHARACTERS AND MODE OF LIFE.

CHAPTER I.

INTRODUCTION.

The Uredineae, or rusts, constitute one of the most important groups of parasitic fungi, and their ravages are known wherever plants are cultivated. The cereals and grasses of our fields, the fruit trees of our orchards, even the ornamental plants of our gardens, and many of our forest trees are attacked by members of this family, and their study is not only interesting from the point of view of the scientist, but from that of every grower of plants for pleasure or for profit. Rusts are usually so conspicuous that they attract the attention of even the ordinary observer, and they have been known and recognised even from the earliest times, particularly from their blighting effects on the wheat and corn crops.

Although so long known as regards their naked-eye characters, and the effects they produce, their structure and life-history have only been understood within comparatively recent times, and even now there are many points concerning them which await investigation.

Their structure essentially consists of an inconspicuous mycelium bearing the usually conspicuous spores, and while this vegetative mycelium is generally similar throughout the group, the spores produced by it are very dissimilar. The general study of this group will therefore mainly resolve itself into a knowledge of the different spore forms, and their relation to each other, either on the same plant or on different plants. The finishing spore or *teleutospore* may be regarded as the ultimate stage of the Uredineae, and which, after usually resting for a period, long or short, germinates by putting forth a germ-tube, which bears, in turn, another kind of spore. The germ-tube is known as the *pro-mycelium*, and the spore as the promycelial spore, or *sporidolum*, so that if the latter is regarded as the starting point, the teleutospore will constitute the finish.

Between these two forms there may be various intermediate stages, and the series may consist of the following:—

1. The *sporidolum*, when it produces its germ-tube, enters the tissues of the host-plant, and may either produce from its mycelium *teleutospores* similar to those from which it originated; or
2. It may give rise to *uredospores* at first, and subsequently *teleutospore*; or
3. It may produce *aecidiospores*, *uredospores*, and *teleutospores* in succession, the *aecidiospores* being generally preceded or accompanied by a peculiar form of spore, known as a *spermatium*.

Hence the complete series of spore-forms will be spermatium, aecidiospore, uredospore, teleutospore, and sporidolum, although between the initial sporidolum and the final teleutospore, one or more of the above may be suppressed or omitted in the life-cycle.

This succession of spore-forms may be represented graphically by the following diagrams:—

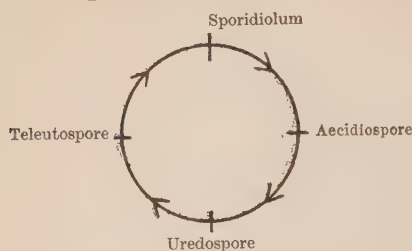


FIG. 1.

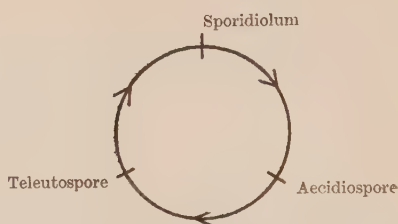


FIG. 2.

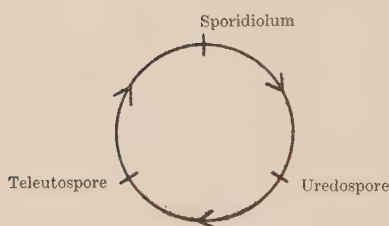


FIG. 3.

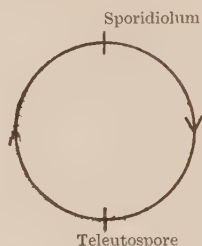


FIG. 4.

The first shows the complete cycle of development in which all the spore-forms follow each other in invariable order, and this is the most common form. In the second the uredospore is suppressed, and the number of species undergoing this contracted cycle is much reduced. In the third the aecidiospore is wanting, and the number of forms is still further reduced. And in the fourth the cycle of development is reduced to its lowest limits, a direct succession of teleutospores occurs, and the number of species, instead of reaching a minimum, probably ranks next to those with a complete development.

The spermatia succeed the sporidiola, and are generally present in the life-cycle, but they do not enter into the general development.

Besides these regular forms, there are others which are generally regarded as representing either stages in the life-history of imperfectly known species or degraded forms of which only the uredospores or aecidiospores are known.

The subject, therefore, naturally divides itself into a consideration of the vegetative organs or mycelium and the various reproductive bodies or spores enumerated above, together with the structures accompanying them.

The life-history of each form, as far as known, will be briefly sketched; but this has still to be investigated in most of the recorded species.

CHAPTER II.

VEGETATIVE ORGANS—MYCELIUM.

The vegetative portion of many fungi is very inconspicuous as compared with the reproductive, but its importance is not to be measured by its size or extent, rather by the part it plays in the life of the organism; and since it is the foundation of the whole, it is worthy of the most careful study.

Of late years, however, this part has come into special prominence, particularly in the case of the cereal rusts, for it has been asserted that it is not always by external infection that the rust begins its career in the growing plant, but that in some cases it originates from within, and this theory will engage our attention later on. Meanwhile this is referred to to show that the key to the propagation of the rusts from year to year may be not only on the surface, among the special reproductive bodies which spread it throughout the growing season, but also in the interior among the cells where the first beginnings of its life may appear.

Among the recent investigations on the mycelium, there are two which stand out on account of their completeness, owing to the use of the most modern histological methods—the one by Professor Marshall Ward⁹ on the *Histology of Uredo dispersa* Eriks., and the *Mycoplasm hypothesis*, and the other by Professor Eriksson^{14, 15} on *Das vegetative Leben der Getreiderostpilze* [The Vegetative Life of the Cereal Rusts]. The study of an individual case will prepare us for the more general examination of the mycelium throughout the rusts, and we will begin with that of *Puccinia dispersa* Eriks., or, strictly speaking, *P. bromina* Eriks., which Ward has so thoroughly dealt with and illustrated with such admirable clearness.

Starting with the germination of the uredospore on the surface of the leaf, which usually occurs within twenty-four hours, we find that the young germ-tube grows rapidly, and that the nucleus of the spore passes into it; sometimes, however, two or more nuclei may appear in it. The tip of the tube begins to swell over a breathing pore or stoma into a thin vesicle, and the contents derived from the spore accumulate here.

This external vesicle or *appressorium*, as it is called, is the first stage in inoculation from the outside, for a thin process is passed through the opening of the stoma, and swells inside into another vesicle. The protoplasmic contents are transferred from the external to the internal vesicle, and so the future growth takes place among the tissues of the leaf.

At one or more points this inner swelling forms a delicate tube, into which the protoplasm is again transferred, and its nucleus soon divides. This is the first-formed *hypha*, and the foundation of the vegetative system. It soon branches and develops cross partitions or *septa*, and extends rapidly among the cells of the host-plant to form the *mycelium*. Even at an early stage, when the primary hypha is still unbranched and unseptate, suckers or *haustoria* may be formed to provide a large imbibing surface for the fungus. The haustorium begins as a small delicate process or projection from the hypha, and this pierces the cell-wall and swells up into a minute spherical head, which is provided with a nucleus. Shortly after entering the cell this head takes on an irregular growth, and may assume a variety of shapes.

The mycelium now becomes denser towards the surface, and prepares for the production of the reproductive bodies or spores. This constitutes the history of the mycelium from the time it starts as a germ-tube until it reaches its full development.

Eriksson has investigated on similar lines, and fully illustrated the mycelium of *Puccinia glumarum*, Eriks. and Henn., but with this important difference that instead of starting with external infection from a spore, he begins with an assumed internal germ of disease, which he considers in certain cases to be a source of rust, in addition to the ordinary infection by spores. It is often stated that this rust passes the winter as mycelium in such leaves as are attacked in late autumn, and which persists till the following spring; but the examination of hundreds of sections of leaves taken from rusty plants, although not rusty at the place chosen for section, failed to reveal the presence of such a mycelium dormant in the tissues. It may be taken for granted, then, that there is no mycelium to start with, and it will be interesting to follow Eriksson's theory as to the manner in which the mycelium arises afresh in the tissues. In certain cells of the autumn and spring leaves a peculiar thick plasma is found, containing a distinct nucleus, and this Eriksson considers to be, not the ordinary protoplasm of the cell, but a mixture of it, with the earliest vegetative form of the fungus. This intimate mixture or symbiosis, or living together of the ordinary protoplasm of the host and that of the fungus he distinguishes as *mycoplasm*. This mycoplasm is stated to occur only in certain cells, which favours the assumption that it is not a necessary constituent of the cell.

The next step and the youngest stage of mycelial formation, according to Eriksson, is the presence of a plasma in the intercellular spaces, which is partly in the form of growing filaments, partly as irregular masses. There are no septa, and no distinctly recognizable nucleus, and even a distinct wall is not formed. The primary stage is quickly followed by a secondary stage, in which the only visible advance is a very distinct nucleus. These two stages are very sharply marked off from the normal mycelium, both by their plasmodia-like nature and the absence of transverse septa, and for distinction the special name of *protomycelium* is given. Eriksson has no doubt that the intracellular mycoplasm and the intercellular protomycelium are genetically connected, but this, which is a necessary link in the chain of evidence, requires to be further investigated. (Note 1, p. 74.) The formation of *haustoria* is the next process, and consists in a small straight prolongation of the protomycelium passing into the interior of the cell, and at the apex forming a globular swelling, probably containing a nucleus. Soon the whole forms a sac-like irregular organ, which may become detached from the protomycelium. These detached bodies in the cell were mistaken by Eriksson for a preliminary stage in the formation of hyphae, and called "special corpuscles," but Ward pointed out their true nature, and that they really had been formed by, instead of giving rise to the hyphae, a correction which Eriksson himself has acknowledged. The haustoria are often found closely adjoining the nucleus, which thereby degenerates, and simultaneously with the shrinking of the nucleus, and soon after the first entrance of the haustoria, transverse septa begin to be formed in the protomycelium. In most of the cells thus formed several nuclei are contained, and the stage is now reached where a true mycelium is present, composed of hyphae.

This multiplication of the cells of the fungus is a sign of advancing maturity. By continued division a true *pseudo-parenchyma* is formed, and at certain spots, where the cells appear to be particularly rich in food-material, a kind of hymenium arises, from which ultimately the spores are detached. Where spores are being formed, there the complete destruction of the cells of the host-plant occurs, and now the vegetative life of the fungus is ended, and the reproductive phase is entered upon.

Perennial Mycelium.—In contrast to the localized mycelium, there may be a mycelium with unlimited growth which does not confine itself to particular spots, but may permeate entire shoots, or even the whole plant. This is known as a perennial mycelium, and wherever it occurs the fungus may reappear on the same plant year after year without the necessity for reinfection by means of spores.

This vegetative reproduction through a perennial mycelium is not always easy to prove, but its importance cannot be overrated, for hidden in the tissues of the plant it cannot be reached by the ordinary means for controlling the growth and spread of fungi, but involves the destruction of the plant, or at least of those parts which harbour it. As Australian examples, we may note *Uromyces trifolii*, which attacks the white clover (*Trifolium repens*) and *Phragmidium subcorticium* or rose-rust, in which the mycelium of the aecidial stage penetrates all the tissues, and in each succeeding year forms a new layer beneath the old.

Uromycladium notabile and *U. tepperianum* occurring on species of *Acacia* are further examples, for the mycelium gives rise to large galls, which persist from year to year and produce spores.

Even although the host-plant is an annual, and dies down every year, it is still possible for the mycelium to be perennial, for it may be carried over winter in the seed, as in the case of *Uromyces euphorbiae*, according to Carleton³.

Witches'-brooms.—It is not unusual among the forest trees and shrubs of Europe to find shoots very much deformed and distorted, and looking at a distance like large birds' nests or brooms, and to these the popular name of witches'-brooms has been given. These peculiar and diseased conditions were difficult to account for, and so the idea may have originated with superstitious people that the trees were bewitched, in order that the witches might be provided with brooms for their midnight rides, hence the name.

But the true cause is seen when the matter is investigated in the light of our present knowledge, and parasitic fungi are often found to be responsible for the strange transformations of the normal shoots into the dense twiggy, irregular tufts met with. This may also be produced by other means, such as gall-mites, but a very striking case and the first recorded instance in Australia is that of the rust-fungus, *Cronartium jacksoniae*, which deforms the shoots of various leguminous plants as shown in Pls. XXXVII., XXXVIII. *Uromycladium tepperianum* also produces this peculiar appearance on *Acacias* as shown in Pl. XLII.

The perennial mycelium in the shoots stimulates a number of buds to abnormal growth, quite different from the ordinary, and the result is seen in the numerous densely crowded and considerably altered shoots as compared with the normal. They are also thickly studded with the ruddy brown columns of teleutospores, in the case of *Cronartium*, which stand out like so many curved or straight, stiff bristles, towards the ends of the shoots, which are gradually being destroyed. Next year the mycelium will grow into the young shoots and produce the same result.

Formation of Galls.—It is well known that the mycelium of fungi exercises a stimulating effect upon growth, and not only causes the cells to grow larger and divide more frequently than usual, and the chlorophyll to disappear, but it may alter the character of the tissues. When an insect pierces the young and living tissue of a plant with its proboscis or ovipositor, it often causes the cells immediately surrounding it to grow and divide more rapidly than elsewhere, so that a swelling of the tissue occurs, which is known as a gall. So among the rusts there are instances where the stimulation of growth occurs in a marked degree, and if a vegetable gall be

considered as a morbid enlargement of the affected part of the plant, due to parasitic agency (Connold¹), then there need be no hesitation in calling these structures galls.

Perhaps the most striking illustration of a gall is seen in *Uromycladium tepperianum*. In the neighbourhood of Melbourne hedges of Kangaroo Acacias (*A. armata*) are being gradually and completely destroyed by the ravages of this fungus, which resemble on a superficial view large galls caused by insects. Most of the branches, including the phyllodes, are infested with the chocolate-brown swellings, which may be in the form of a succession of small excrescences about the size of peas, or collected into large clumps about the size of walnuts, and measuring 4 cm. across. In some cases they are solid round knobs, and the external appearance is due to the dense covering of the chocolate-brown teleutospores. One of the largest was met with at Myrning on *Acacia implexa* of an irregular leg-of-mutton shape and weighing about 3 lb. (Pl. XLI).

On *A. pycnantha*, or Golden Wattle, the galls are as large as potatoes, and in some of the wattle plantations, where the trees are cultivated for their bark, they hang in large numbers from the branches like so many fruits, and numbers of the trees are either dying or dead. The swellings are primarily caused by the fungus, and then various insect larvae may ultimately invade them, boring and tunnelling through them. In *A. implexa* the swellings may run along the whole length of the elongated phyllodes, and in *A. salicina* there is an all-round swelling of the branches, and the periderm is ultimately ruptured. Magnus³ found the galls to be permeated by an intercellular mycelium, which was multiseptate with numerous and somewhat branched haustoria.

Some very large galls were also found on the Black Wattle (*A. decurrens*) and Silver Wattle (*A. dealbata*) either surrounding or terminating the branches, and caused by *U. notabile*. Some measured 4-5 inches across, and 3-4 inches was not uncommon, while one of the largest weighed 15 oz.

The peculiar gall-like swellings caused by *Gymnosporangium* may be mentioned, the mycelium of which is perennial in the various species of Juniper, and from their appearance are popularly known as "cedar apples" in America. It may be an annual gall only bearing the teleutospores for one season, or a perennial gall, producing successive crops of teleutospores year after year, and not requiring the transfer of the spores each season.

Localized Mycelium.—The localized mycelium may likewise produce conspicuous swellings, particularly on the stem and midrib of the leaves. Thus, that of *Aecidium urticae* causes hard curved thick swellings of considerable extent, and such a development of starch takes place in some Himalayan species of nettle attacked by this fungus that the natives eat the overgrown and hypertrophied stems for food.

In other cases the affected tissues may be so stimulated by the localized mycelium as to cause their death. Thus almond leaves have been found here badly riddled with "shot-hole," due to the mycelium of *Puccinia pruni* Pers, just as *P. malvacearum* may also destroy a circumscribed area which becomes separated around its circumference, and falls out, leaving a circular hole.

The mycelium, whether localized or perennial, is always beneath the surface of the plant, and formed within the living tissues. It is delicate in texture, like all internal mycelia, and branches to form a regular network, ultimately forming compact cushions or spore-beds. It can often be traced from a single point of infection, whence it radiates all round and spreads, gathering material for the fresh production of spores.

CHAPTER III.

REPRODUCTIVE ORGANS—SPORES.

A detailed account of the different spore-forms will be given in the systematic part in connexion with the various species; but it will be convenient here to take a preliminary view of some of the more essential general features, such as distribution, germination, and infection, suppression or omission, and repetition of spore-forms.

DISTRIBUTION.

The most important means of distribution of the rust-spores, as for fungus spores generally, is the wind. They are usually exposed on longer or shorter stalks, often powdery, and their immense numbers and lightness all render them easily detached, and spread by the slightest breath of wind.

That the wind is an important factor in the distribution of rust-spores is strikingly shown in an example given by Halsted¹. The asparagus rust (*Puccinia asparagi*, DC.) was very bad, but in one field the plants had been cut over, and the rusty brush removed in order that the new growth might escape. On examining this field about five weeks afterwards, he found that the rust showed only on one side of the green plants, and that was the side exposed to an old and very badly rusted asparagus bed. That this was the source of infection was obvious from the fact that a house with a few trees around it intercepted a portion of this field, and there was less rust upon that portion of the new bed in line with the house.

The dust-storms which occur will also be a fruitful source of spreading them, and in our northern areas where the dust is sometimes carried in such quantities as to obliterate fences, it can easily be understood how even in virgin soil the spores of wheat rust may be found.

The rain will also help to scatter them, particularly over individual plants, and on the surface of the soil, for it is a common observation how rusty plants are cleared after a heavy shower.

Insects as well as other animals serve the same purpose. I have often observed the larvae of a species of *Cecidomyia* feeding on uredo and aecidio-spores, and at the same time spreading them while crawling along. Lindroth¹ has observed in Finland the occurrence of these larvae on no less than sixty-one species of rusts, and similar larvae have been found feeding on the conidia of various species of *Oidium* (Salmon¹). In some pot experiments with wheat, I found the larvae associated with the *Oidium* of *F. graminis*, and feeding on the conidia. At first sight it might seem as if this devouring of the spores would tend to reduce the fungus, but the wholesale way in which the spores are carried about more than counterbalances any decrease from this cause.

GERMINATION.

As a rule, uredo and aecidio-spores germinate easily in a damp chamber, and I have found the method recommended by Plowright to be very convenient. A gardener's propagating glass is used, placed on a plate of water, and a simple stand is made with two flat oblong pieces of gutta-percha. Holes are easily bored in them, and glass rods placed parallel between them, so that the microscopic slides may be laid across the rods.

The influence of various chemical substances on germination has been investigated, and it has been found that some substances, such as solutions of sugar and nitrate solutions, hasten germination; but for general purposes water alone is all that is necessary. Sometimes, however, the spores will germinate and infect the leaves of the host-plant, although they may not do so in water.

Freeman¹ found this to be the case in dealing with the uredo-spores of *Puccinia bromina*, and concludes that the negative results in distilled water tests are not always an indication that the spores are incapable of germination. The temperature seems to exercise an important influence. Eriksson found that in many cases the spores germinated more freely if previously exposed to a temperature of 0 deg. C. or under, and Marshall Ward that the uredospores of *P. bromina* were not injured by being exposed to a temperature of - 5 deg. C. for ten minutes, while the same temperature continued for four to five hours killed them. Heat or cold, drought or damp, age and ripeness, are all factors of importance in germination.

DURATION OF GERMINATING POWER.

How long do the spores retain their germinating power is an important question to settle; but not many definite determinations have been made.

De Bary states that the uredospores of *P. graminis*, kept dry, lose their germinating power in one to two months.

Marshall Ward found that the uredospores of *P. bromina* preserved dry for sixty-one days retained their germinating power; but it was feeble.

Barclay found certain uredospores still capable of germination after from two to eight months, the leaves on which they occurred being kept dry.

It is a question of great scientific interest in connexion with rust in wheat if the uredospores can retain their germinating power during the winter. The results vary, as might be expected, according to the conditions prevailing at the time. In contrast to De Bary's results, Eriksson found that the uredospores of *P. graminis* lost their germinating power during the winter if kept in the open, but retained it if kept inside. Hitchcock and Carleton¹, however, collected fresh uredospores from growing plants of *P. rubigo-vera* at various times during the winter, and found them capable of germination. In our comparatively mild winters the uredospores retain their power of germination, and this seems to be the means whereby the fungus is continued from season to season. I have had freshly gathered uredospores of *P. graminis* from growing wheat and oats, and *P. triticea* from wheat germinating freely in water in winter (June to August). The uredospores can germinate at once, and directly infect the host-plant, or they can act as resting spores for a time, and freely infect the next season's growth, under the climatic conditions which prevail here.

The germination of teleutospores takes place at different periods, according to the nature of the species. They may either germinate immediately on reaching maturity, or, as is the case in the majority of heteroecious rusts, only after undergoing a period of rest—in the old world usually in the winter, but here, as no doubt sometimes elsewhere, the period of rest is often partly in the summer, when drought checks growth as effectively as the cold of a European winter.

Eriksson¹⁰ has shown that the teleutospores of *P. graminis*, with few exceptions, only germinate in the spring following their formation, and only then if kept in the open during the winter. He kept spores in the herbarium for one or two winters, and then on exposing them for another winter, he found that they germinated, but this was exceptional.

In other species there is considerable variation. According to Woronin¹, the teleutospores of *P. helianthi* germinated equally well when kept dry in a room, or when taken from the leaves of a plant which had been under the snow all winter; and Carleton³ found them to germinate even without a resting period.

After wintering, Eriksson found that the teleutospores of *P. graminis* could retain their germinating power even to the beginning of autumn—September in Sweden.

In Victoria the germination of the teleutospores of *P. graminis* has been tested for several seasons, and it is found that after a period of rest extending over about eight months, and including the usually hot and dry summer, they begin to germinate in our spring (September), and if the weather conditions are favourable, may retain their germinating power until November. Rusted straw has been kept outside exposed to the weather, and in a room, but no germination took place outside of the above months. When spores have once begun to germinate it is a mistake to suppose that they will all germinate at the same time, for there is a certain irregularity about germination in the open which causes the period of germination to be considerably extended.

INFECTION.

The mode of infection usually varies in different classes of spores. The germ tube of the uredospore or aecidiospore generally enters by the stomata into the tissues of the host-plant, while that of the sporidiolum bores through the epidermis direct, and this difference in the mode of infection influences the stage at which it occurs in the development of the host-plant. The sporidiola are, as a rule, only able to infect young and tender portions of the plant; but the uredospores and aecidiospores can evidently attack old and fully developed organs.

Further, since the germ-tube of the sporidiolum in piercing the epidermal cells must dissolve the wall at the spot where it enters, there is evidently a reciprocal influence exerted between the parasite and its host; but even in the case of the uredospores and aecidiospores, where an entrance is effected through the stomata, there also exists some mutual relation, for it is only in certain hosts that the parasite can grow and develop.

This relation will be more fully dealt with when the origin of parasitism is considered, but meanwhile the fact may be emphasized, that the mere entrance of the germ-tube through the stoma does not constitute infection. Miss Gibson¹ carried out infection experiments with uredospores and aecidiospores of various rusts on a number of plants other than the original hosts, and she found that while the germ-tube may enter the stoma freely, yet, once inside, death ensues sooner or later, and in no single instance was a haustorium formed. The fungus was unable to penetrate the cells of the foreign host-plant, and so died of starvation.

The period which elapses between the entrance of the germ-tube into the host-plant and the appearance of the result is known as the incubation period. During this time the germ-tube grows and ramifies among the tissues, abstracting nourishment from the cells by means of haustoria, and finally proceeds to the formation of fresh spores. The first visible trace of this does not generally appear before eight days, but, according to the nature of the fungus, it may take much longer. Schimper, in his masterly work on Plant Geography, begins with the statement—"No factor affecting plant life is so thoroughly clear as the influence of water," and even for parasitic fungi this factor is of prime importance. Smith¹ has determined the water relation for *Puccinia* on asparagus, and probably the same principle applies in a general way to other rusts. From a study of the direct

relation or the effect of atmospheric moisture upon the spores or mycelium, it has been shown that dew is absolutely necessary for infection, and of more importance than rain, and, in fact, that without dew there can be no infection. Further, that the effects of atmospheric dryness not only influence spore germination, but also spore production, and the aecidial and uredo stages are checked thereby, but if the mycelium is not completely destroyed, the teleuto stage may appear independently of conditions unfavorable to the others. The indirect relation of water or the effect of soil moisture, which acts upon the parasite through its host, has also been studied and shown to be of great importance. An abundance of soil moisture at the growing season, in the case of asparagus rust in California, is stated to increase the vigour and vitality of the host, and retard the development of the fungus. That the growth of the fungus is retarded by increased vitality of the host scarcely agrees with Marshall Ward's conclusions in regard to brome rust (Chap. XVIII.). That the weather exercises a commanding influence in hastening the development of rust in wheat is abundantly shown by its rapid spread in hot "muggy" weather, especially when accompanied by heavy dews. Irrigation before ploughing gives the wheat a good start, but if applied in the spring it makes the wheat soft and very liable to rust, a case in which great vigor of growth of the host is followed by a strong development of the rust.

While the ordinary mode of infection is as stated above, exceptions may occur. Thus, according to De Bary, the germ-tube of the sporidolum of *Puccinia dianthi* (*P. arenariae*) may enter by the stomata, and Bolley⁴ gives illustrations to show that the germ-tube of the uredospores of *P. triticea* may enter direct through the epidermal cells as well as by the stomata.

SUPPRESSION OR OMISSION OF SPORE-FORMS.

As already pointed out in the Introduction, the complete cycle of development follows an invariable order. The germinating teleutospore gives rise to sporidiola, from the mycelium of which arises the spermogonia and aecidia; later the uredospores appear, and finally the teleutospores complete the cycle.

The aecidio, uredo, and teleutospore forms are represented respectively for convenience by the Roman numerals I. II., III., and if the sporidiola arising from the teleutospore are designated by IV., and spermogonia by a cypher, then it will be comparatively easy to represent the different stages diagrammatically. A complete cycle of development will be represented thus—O., I., II., III., IV.

The teleutospore with its sporidiola is believed to be a constant factor in the cycle, although there are various rusts in which it has not yet been found, so that I. or II., or both, may be omitted or suppressed, as well as O., which, however, is rarely absent. The germinating sporidolum produces a mycelium which may in turn give rise to spermogonia and aecidia. These may either occur on the same species of host-plant as that which bears the teleutospore, and the rust is thus said to be *autoecious*, or they may occur on a totally different plant when the rust is said to be *heteroecious*. The aecidio-spore on germinating may skip the uredo stage, and directly produce the teleutospore, and thus the cycle is shortened. There are numerous examples of this in Australian forms, among which may be mentioned the rust on the marigold (*P. calendulae*), and that on the daisy (*P. distincta*).

This variation in the alternation of spore-forms has been used by Schroeter as a basis of grouping, and although these biological sections by no means indicate close affinity, yet they conveniently group together forms which have similar associated stages. Taking the genus *Puccinia* as an

example—and it applies to other genera as well—the complete cycle is designated *Eu-puccinia*, and represented diagrammatically as O., I., II., III., IV.

Then the stage in which the uredo does not appear is known as *Pucciniopsis*, and represented by O., I., III., IV. Again, the germinating sporidiolum may produce a mycelium which bears spermogonia and uredospores, thus skipping the aecidial stage. This stage is called *Brachy-puccinia*, and represented by O., II., III., IV., or the spermogonia may likewise be suppressed when practically only half of the cycle is retained, and it is known as *Hemi-puccinia*, represented by II., III., IV. This is a stage which is probably based upon imperfect observation, and the presumed absence of the spermogonia. Further, the germinating sporidiolum may skip the aecidial and uredo-stage and produce the teleutospore direct, with its accompanying spermogonium. This is known as *Lepto-puccinia* when the teleutospore germinates immediately, and *Micro-puccinia* when it undergoes a period of rest. It would be represented diagrammatically as O. III., IV.

As might be anticipated, the greatest number of species have a complete life cycle, and next to that come probably those species in which the life cycle is reduced to its lowest limits, thus showing that the aecidial and uredo generations may be dispensed with. In the former case there is, as it were, a succession of forms adapted to the varying seasons, well fitted to meet any sudden changes, and living upon the same, or having a change of host-plant as may be found most convenient, while in the latter the change consists not in the variety of spore-forms, but in having a general purpose spore, which can either germinate upon the living plant as soon as it reaches maturity or undergo a period of rest in the decayed organic matter before producing sporidiola. Hollyrock rust, or *Puccinia malvacearum*, is a good illustration of a single-spored form adapting itself to the most varied conditions, and making its way in the world.

The complete scheme for grouping Puccinias, according to the alternation of their spore-forms, is as follows:—

Eu-puccinia, O., I., II., III., IV.

Pucciniopsis, O., I., III., IV.

Brachy-puccinia, O., II., III., IV.

Hemi-puccinia, II., III., IV.

Lepto-puccinia, O., III., IV. (Teleutospores germinating immediately).

Micro-puccinia, O., III., IV. (Teleutospores germinating after a period of rest).

REPETITION OF SPORE-FORMS.

In connexion with the suppression or omission of spore-forms, we may also consider the repetition of spore-forms, because it would appear that in many instances the suppression is brought about or initiated by one of the spore-forms being able to repeat itself in the course of the cycle, and thus making up for the loss of one member of it. It is the doctrine of substitution in another form. This will be more conveniently dealt with when treating specially of the aecidio and uredo spores, where it will be seen that when the uredo generation is suppressed or omitted, the aecidio-spores often repeat themselves, and when the aecidial generation is omitted the uredospores repeat themselves.

INVESTIGATION OF SPORES.

The microscopic investigation of rust spores is comparatively easy, although it requires careful observation with regard to their minute details.

If the loose spores are examined as to their individual structure, whether aecidio uredo or teleutospores, it is simply necessary to mount them direct, and I find the most convenient mounting medium to be glycerine and water, in equal proportions. For permanent preparations glycerine jelly may be preferable; but for the rapid examination of material the above serves very well, and where desirable the mount can be preserved. The surface markings of the spores are often obscured in mounting, and have sometimes been overlooked by otherwise good observers. As a general rule, they are best seen in the dry condition and without any special preparation, but they are usually also seen in glycerine and water, especially if examined when freshly mounted.

The number and position of the germ-pores require to be carefully studied, since they are often of specific value, and there are various reagents which show them up with great clearness. Among these, I have successfully used lactic acid and Bismarck brown.

A 50 per cent. solution of lactic acid was used as a mounting medium, then the spores were added, and the slide was heated over a spirit-lamp just until the liquid reached the boiling point. Sometimes it is necessary to boil for a little in order to get the best results, taking care not to burst the spores, but as a rule bringing it to the boil is sufficient. After the preparation has cooled, the cover-slip is placed over it. Some use a mixture of equal parts of glycerine and alcohol for mounting the spores before adding the acid.

Boiling in lactic acid not only drives out the air and makes the spores more transparent, but it swells them to their normal shape and size, and not only brings out the germ-pores, but the surface markings as well. For pale-coloured spores or spores which have partially lost their colour through age, I have found nothing to surpass Bismarck brown. The clear germ-pores show up well against the brown stain. The spores are simply laid in the smallest possible amount of water or water and glycerine on a slide, then thoroughly separated by stirring with a needle. Sufficient of the stain is next applied, covered, and after gentle boiling the spores are ready to be examined. It stains quickly, but does not overstain, and is fairly permanent.

Soaking hard tissues for twenty-four hours in a solution of caustic potash or caustic soda softens them wonderfully, and mounts made from minute pieces of the material thus treated are often extraordinarily beautiful, and the relation of the parts to one another is preserved in a surprising manner. Though soaking for several days nearly always destroys the colour of the spores, yet details may sometimes be distinguished with a certainty not obtainable by any other method.

For determining the average size and shape of the spores I know nothing better than photography. Numbers of spores are photographed together, and the general shape can be determined by comparison, while the size is deduced from the exact measurement of individuals in large groups. In this way the average size has been obtained for the teleutospores chiefly, of all the species accessible for observation. At the same time a large number were measured direct by an eye-piece micrometer and the results compared. All the microscopic investigations were made with Zeiss' apochromatic objectives, and the photomicrographs with lenses of Watson's holoscopic series.

CHAPTER IV.

SPERMOGONIA AND SPERMATIA.

The spermogonium, sometimes called *pycnidium*, is a small punctiform body, hemispherical to flask-shaped, produced beneath the epidermis or cuticle, and ultimately the narrow neck bursts through in order to allow the contents to escape into the air. The narrow opening is generally surrounded by a brush of sterile projecting stiff hyphae, the so-called paraphyses, and in the interior of the spermogonium there are numerous converging hyphae surmounted by very minute oval or rounded bodies borne in short chains—the so-called spermatia. These bodies were considered to be of the nature of male sexual organs, hence the name; but whatever may have been their original function, now lost in the course of development, there is no reliable evidence to support the view of their being sexual in function.

The spermatia are embedded in a sugary secretion, and though it is not known whether this serves to cause the spermatia to germinate, insects are probably attracted to the spermogonia sometimes by means of this sweet bait, and also by their powerful and penetrating odour, as in *Puccinia suaveolens* Pers., which is so named on account of its sweet scent. The honey colour of the spots may also serve as an attraction, and the projecting hairs or paraphyses are believed to retain the spermatia and prevent them being washed away.

Colour, scent, and honeydew will thus co-operate in alluring insects to the spot, and the evident resemblance of these relations to those which prevail in the fertilization of flowers by insects naturally led to the belief of the spermogonia and spermatia being concerned in some way with the fertilizing process. This view was further strengthened by the fact that in Lichens, which possess similar structures, there called pycnidia, a true process of fertilization occurs. But actual experiments fail to prove any such connexion, and the probabilities are that the original function has disappeared owing to modifications consequent upon the fungus becoming parasitic. Spermatia do not germinate in water, but do so when placed in a suitable nutritive solution, such as white cane-sugar dissolved in water. Germination consists in a minute prolongation at one end, which ultimately becomes like the parent spore, and thus, as far as present knowledge goes, the spermatia are isolated structures, and do not enter into the regular development of the fungus.

Spermatia, whatever may be their function, do not occur as solitary spore-forms, but always precede or accompany one of the others. They are usually associated with aecidia, but this is not invariably the case, for there may be aecidia without them, and in the absence of aecidia they may be associated with other spore-forms, such as uredospores in the case of *Uromycladium robinsoni*, *Puccinia hieracii* (Schum.) Mart. &c., and teleutospores, as in *P. liliacearum* Duby and *Uromycladium tepperianum* (Sacc.) McAlp., and either uredo or teleuto spores, as in *U. maritimum*. The same mycelium which proceeds from the teleutospores, and produces the spermogonium, also produces aecidio uredo or teleutospores, as the case may be, although it may seem a needless waste of material and an unnecessary act, since the one is left behind in the race, while the others

continue their further development. In a paper by Arthur³ on the *Taxonomic Importance of the Spermogonium*, he shows that, in the first place, the presence of the spermogonium, along with its associated spore-forms, gives important information regarding the length of the life-cycle. Thus he concludes that if spermatia and uredospores arise from the same mycelium, aecidia do not occur, and if spermatia and teleutospores thus arise, neither uredo nor aecidio spores will occur. There are cases, however, in which the spermogonia are found in association with both uredo and teleuto spores, as in *Uromycladium maritimum*, *U. notabile*, and *U. robinsoni*. When the spermatia are associated with aecidia, it is only where teleutospores and aecidia arise from the same mycelium that it can be definitely stated that there are no uredospores.

In the second place, the characters of the spermogonium, such as position, size, form, and colour, and its relative position to the accompanying spore-forms, furnish characters for positive identification, although of minor value. There is an interesting relation of the spermogonium to other spore-forms to be noted in the cases afterwards referred to, where there is a *repeated* formation of aecidiospores, uredospores, or teleutospores, as the case may be, and these spore-forms do not directly proceed to their normal development. In such cases, as far as our present knowledge goes, the spermogonium is the only one which does not repeat itself, as stated by Arthur³:—"An observation more pertinent to our inquiry is that the spermogonium occurs but once in the cycle, not being repeated with each generation of repeating aecidia or uredo. In case the teleutospore takes on the conidial function (repeating process), it is uncertain whether the spermogonium is repeated with each summer generation or not. In *Puccinia malvacearum* and similar Lepto-Uredineae, the spermogonium seems to be wholly suppressed even with the first generation in spring."

The question of sexuality has been raised in connexion with the presence of nuclei, but what constitutes an act of fertilization is interpreted differently by different authors.

Sappin-Trouffy², for instance, has observed in Uredineae having the various stages the following nuclear cycle:—

Uni-nucleate.—

Mature teleutospores.

Sporidiola.

Mycelium, producing spermatia and aecidiospores.

Spermatia.

Bi-nucleate.—

Aecidiospores.

Mycelium, producing uredo and teleutospores.

Uredospores and

Young teleutospores.

In the mature teleutospore the two nuclei fuse, and this fusion was regarded by Sappin-Trouffy as an act of fertilization, but the fusion of the nuclei may be interpreted otherwise. Blackman² has confirmed the above nuclear cycle, and concludes that the spermatia are male cells which have become functionless, the nuclear characters being those of male cells and not of spores.

The fertile cell of the aecidium or primary aecidiospore becomes bi-nucleate by the nucleus of a neighbouring vegetative cell migrating through the wall, and this association of the two nuclei Blackman considers to be fertilization rather than the act of fusion in the teleutospore, since the fertile cell is stimulated to further development by the entrance of a nucleus from without.—(Note 2, page 75.)

Massee also considers the aecidium to be a sexual product, and both authors agree that the spermatia are not concerned in it. If the spermogonia and aecidia represented male and female reproductive organs, a distinct alternation of generations would be present, the spore-bearing stage or sporophyte commencing with the fertilized cell in the aecidium, and the egg-bearing stage or gametophyte starting with the uni-nucleate teleutospore. But the most probable view is that the spermatium is a functionless organ, and its presence is an indication that the ancestors of the rusts may have possessed an alternation of generations similar to that referred to above.

CHAPTER V.

AECIDIA AND AECIDIOSPORES.

The aecidia, or cluster-cups, as they are often called, are usually brightly coloured, and attract attention not only from their colouration, but from their elegant forms as well. The mycelium derived from the germ-tube of a promycelial spore may first produce its spermogonia, and then proceed to the development of aecidia, or aecidia may be succeeded by aecidia. The spore layers are contained in a receptacle or pseudo-peridium, which is formed from a simple layer of flattened sterile cells. It increases in size by the formation of new cells at its base, and is cup-shaped or cylindrical, rupturing at the apex to allow the escape of the spores.

The aecidiospores are always unicellular, and are arranged in linear series, arising from densely-crowded, erect hyphae or basidia in basipetal order. The young spores are at first separated from each other, according to De Bary, by sterile, intermediate cells, which are soon, however, absorbed, and this makes it often difficult to prove their presence. From the mode of their formation, from above downwards, the ripe spores are at the top, and readily separate to be blown away, while the young spores become polygonal from mutual pressure, lateral and lengthwise.

The spores have usually a colourless membrane, with the exception of those of *Gymnosporangium*, in which it is usually a deep brown, and in the great majority of species are provided with points, spines, or warts, to make them adhere in order to germinate. The granular contents are coloured, as a rule, with an orange-yellow or orange-red oil, although this also occurs in many uredo and teleutospores.

Germination takes place as in the uredospores by means of a simple cylindrical germ-tube which enters through the stoma into the interior of the host-plant. At certain weak spots in the membrane germ-pores are formed, which are usually only distinctly visible at germination, owing to the swelling of the membrane at these spots, and through these the endospore is protruded in the form of a tube. As the aecidiospore germinates very readily in water, the process of germination can be easily followed. A germ-tube rarely arises from more than one pore, and the contents of the spore gradually pass into it along with the orange-colouring matter, so that the spore is ultimately emptied and the endochrome is towards the extremity of the tube.

I found aecidiospores of *Puccinia tasmanica*, from the common ground-sel (*Senecio vulgaris*), to germinate freely in the manner indicated. They were very plentiful in November, and in a drop of water they began to germinate within a few hours, and soon produced germ-tubes of considerable length.

As to the length of time that aecidiospores retain their germinating power there is much difference of opinion. De Bary states that they may retain it for some weeks, while Plowright considers it a matter of hours. Eriksson, on the other hand, found that the spores of *Aecidium berberidis*, for instance, were very capricious and uncertain in their germination, but there is always the possibility that although the spores do not germinate in water, they may infect a host-plant when brought into direct contact with the living leaf.

According to Bolley, the aecidiospores on barberry and other hosts are still capable of germination, even after lying in the herbarium for some time, or being sent through the post.

The development of the aecidia has been traced by De Bary, Neumann¹, and others. The hyphae derived from the promycelial spores form at certain points, deep down in the parenchyma of the leaf, little compact bodies which have been called primordia by De Bary, because they are the beginnings of the aecidia. These bodies gradually increase in size by the rapid multiplication of the mycelium until they assume a spherical form, only being slightly flattened at the part immediately beneath the epidermis, and considerably thickened at the base. If sections are made at this stage the differentiation of the cells is seen to have begun. From the dense basal layer of hyphae arise numerous, closely-crowded, short, erect hyphae, somewhat club-shaped, and generally known as basidia. From each of these erect hyphae an apical cell is separated off, and beneath that another, and so on until a linear series is formed. At the same time, as the basal cells give rise to the so-called basidia, the surrounding cells develop into the external envelope or peridium. At first they are absolutely indistinguishable from the others, but after the third or fourth division they are seen to be much broader. Then, simultaneously with the formation of the first spores, they acquire their characteristic markings and polygonal form. At first the peridial cells are filled with the coloured protoplasm or endochrome, but the colour gradually disappears.

With regard to the peridial cells, Fischer¹ has shown that in *Gymnosporangium* the sculpturing of the walls may be used for the distinction of species, and while in the genera *Puccinia* and *Uromyces* these cells are much more uniform in their markings, yet there is considerable variation. Mayus¹ has examined peridial cells from several species of these two genera, and has found that within the limits of the same species the nature of the peridium undergoes variation under the influence of external conditions. These variations chiefly consist in the relations of the lumen and the thickness of the wall, the lumen being relatively larger in shady places and the converse in sunny places.

The typical aecidium possesses an external envelope of cells or peridium, which surrounds the spores, and when this becomes ruptured at the top to allow the escape of the spores it assumes the form of a cup. But the envelope may assume different forms, or even be absent, and then different names are given to it for convenience, although in its essential character of spore-formation it is still the same structure. When the peridium is elongated, and often horn-like, it is called a *Roestelia*, or it may be rather irregular in shape and confined to coniferous plants, when it is called a *Peridermium* (not represented in Australia), and when the peridium is absent it is known as a *Caeoma*, as in *C. apocyni*.

Even in the genus *Puccinia* the pseudo-peridium is wanting in individual species. In a number of species, as in *Puccinia prenanthis*, the aecidium is sunken and formed by the more or less altered tissue of the host-plant, and a special pseudo-peridium is either completely wanting or very imperfect. Such aecidia are to be regarded as intermediate forms between the true distinctly walled aecidia and the caeoma form.

The origin of the aecidium has given rise to a good deal of discussion, and it is not universally accepted that it originates from non-sexual cells. Masee¹, in his paper *On the presence of Sexual Organs in Aecidium*, considers it to be a sexual product, and has even drawn the swollen ends of two mycelial hyphae imbedded in the tissues of the host-plant, supposed to be in the act of conjugation. Arthur, in his *Problems in the Study of Plant Rusts*,² and *The Aecidium as a Device to restore Vigour to the Fungus*¹ comes to the conclusion that "the aecidium, with its accompanying spermogonia, represents the original sexual stage of the fungus, and that it still retains much of its invigorating power."

But it is quite possible that the time of appearance of the aecidia has something to do with their invigorating power, if such exists. They usually appear in the spring, when the first rush of vegetation commences, and naturally the parasite shares in the strong growth of the host-plant. The nature of the host will likewise affect the result. It may appear on the leaves of an annual such as *Helianthus annuus*, which also bears teleutospores, or on those of a deciduous shrub such as barberry, the uredo and teleutospores of which occur on wheat and other grasses. But it is a striking fact that the aecidium is so rare upon a grass that, until the discovery of an aecidium on a species of *Danthonia* in Victoria, only one instance was known, viz., *Puccinia graminella*, in which the aecidia and teleutospores occur together, the latter being often very rare, or wanting altogether.

Repeated Formation of Aecidia.—The normal development of heteroecious fungi, as well as of autoecious forms, follows a regular cycle, as already shown. In those forms possessing all stages in the life cycle, the sporidiola produce only the aecidia, and the aecidiospores in turn give rise only to uredo and teleutospores, as in *Uromyces trifolii* (Alb. & Schw.) Wint. But among those autoecious species which produce aecidiospores and teleutospores without uredospores, this regular succession of forms may be departed from in some cases, and the aecidiospores, provided the mycelium is not perennial in the host, may repeatedly produce new aecidia before the teleutospores are reached, as in *P. senecionis* Lib.

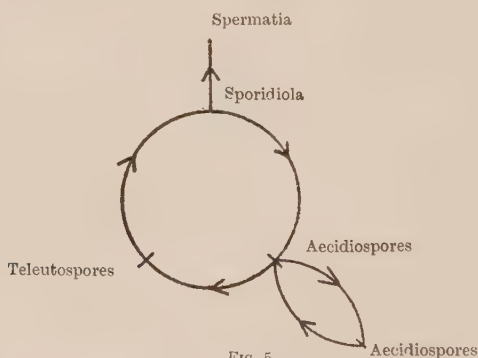


FIG. 5.

This repeated formation of aecidia was principally investigated by Dietel, who named the aecidia arising directly from the germination of teleutospores "primary aecidia," and those arising from the germination of aecidiospores "secondary aecidia;" and it was noticeable that spermatogonia were usually absent from the latter. Thus the germinating sporidium may produce a mycelium which bears only aecidia; but the aecidiospores, instead of giving rise directly to teleutospores, may repeat themselves for several generations, and then give rise to teleutospores. However, in a complete cycle, the aecidia originate only from sporidiola, while in an incomplete cycle the aecidia at first originate from sporidiola, and then repeat themselves.

CHAPTER VI.

UREDOSPORES.

Uredosporae may originate from the hyphae developed from the germ-tube of an aecidiospore, a promycelial spore, or another uredospore. They are generally ovate or elliptic, and are developed singly on the ends of separate short upright hyphae, known as basidia. In some genera, however, such as *Coleosporium* and *Chrysomyxa*, they arise like the aecidiosporae, in short chains, and thus resemble Caecoma-forms—in fact, they are sometimes regarded as such. The spore-bearing hyphae are crowded together just beneath the cuticle, or epidermis, of the plant, and such an aggregation is known as a spore-bed, or sorus.

The uredosporae are always unicellular, and never smooth, the membrane being beset with projections in the form of short prickles (echinulate) or fine warts (verrucose). Two-celled uredosporae have been described and drawn by Roze¹ and Jacky², in *Puccinia chrysanthemi*, but they are very probably monstrosities, as suggested by Sydow, two unicellular spores becoming united when young, and growing up together. In the same rust I found, in one instance, two uredosporae produced on the same stalk, the one slightly beneath the other; but this was merely a freak. They differ generally from the aecidiosporae on the one hand in the mode of formation, and from the unicellular teleutospores of the genus *Uromyces* on the other, in having two or more germ-pores, and this character also distinguishes them from the mesosporae. Only in exceptional cases is there only one, as in *Puccinia monophora*. They vary in colour, generally being some shade of orange or brown, and in the brown spores De Bary has shown that, as in teleutospores generally, the colouring matter is in the wall, and not in the contents.

Germination occurs similarly to that of the aecidiosporae. When ripe, and kept moist, a germ-tube is readily protruded through one or more of the germ-pores, and this enters the host-plant by a stoma, and in the interior develops a mycelium like that from which it originated.

It is interesting to notice that in some cases the uredosporae may be produced, not only at the surface, but within the tissues. This happened with *Puccinia pruni*, in a peach fruit, where spore-beds of rust freely producing uredosporae were imbedded in the tissue, in more or less rounded cavities, up to 5mm. below the surface. The decaying fruit would form a splendid matrix for preserving the spores till next season. Since they are chiefly produced in the summer, and adapted, as a rule, for rapid germination, they are often spoken of as summer spores, and as soon as they arrive at maturity become detached from their stalks.

Repeated Formation of Uredosporae.—Just as aecidiosporae may produce aecidiosporae for several generations, so may uredosporae produce uredosporae. This is well seen, for instance, in *P. graminis*, where uredosporae are produced direct from the uredosporae without the intervention of aecidia and teleutospores, as is the case in Australia, and this repeated formation of uredosporae may continue indefinitely. But there are several cases where the first-formed uredosporae are different from those produced later, and, in order to distinguish such forms, the two kinds of generations are known respectively as primary and secondary.

The primary generation appears in the early spring, and originates either by infection from the promycelial spores, aecidiospores, or, it may

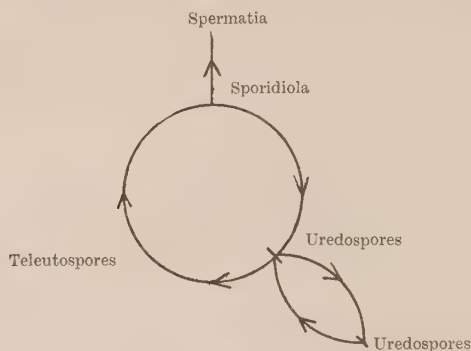


FIG. 6.

he, from a perennial mycelium. The spore-layer is usually distinguished by its larger size, and the corresponding injury it causes to the host-plant; while the secondary generation, produced by infection from the preceding uredosporos, has a smaller spore-layer.

A well-investigated and very striking case is seen in *Triphragmium ulmariae*, in which the primary and secondary uredosporos generally resemble each other; but the sori of the former are much larger and produced in great abundance, occurring on the stalks and midribs of the leaves, while those of the latter are small and scattered on the under surface of the leaf. So striking is the difference that a special name has been proposed for the sorus, *epiteosporiferous* and *epiteosporos* for the primary spore; but it is quite superfluous, since the larger and more prominent sori of the primary generation may be accounted for from the strong vigour of growth in the plant at the time when the first infection occurs.

The wintering of the rust-fungi, in the form of the uredo, depends on the nature of the rust itself, and also on that of the host-plant. If any portion of the host-plant remains green and succulent during the winter, then the fungus has an opportunity of surviving, and it is thus seen that climatic conditions have a deal to do with the persistence of the fungus. When the winter is mild and green vegetation flourishes, the mycelium of the rust fungus may continue to grow, and may even produce spores; whereas, if the winter is severe, and the mycelium does not remain in the perennial parts of the plant, then the continuance of the fungus is likely to be by teleutosporos, which can last through the winter on dead stems or other decaying vegetable matter. This so-called wintering of the uredo depends so much on the climate that in a mild climate the fungus may perpetuate itself exclusively by uredosporos; whereas, under severe conditions, it has to resort to teleutosporos.

A very striking case is recorded by Lagerheim¹, in *Uromyces fabae* (Pers.), De Bary, which in Europe passes through the three stages of the aecidio-, uredo-, and teleuto-spore, while in Ecuador it only produces the uredo-form. Heteroecism, or alternation of generations, is an arrangement suited to conditions where the seasons are variable, but in an equable climate such as Ecuador there is no occasion to produce such a variety of spore-forms, and so the fungus adheres to the one which serves its purpose best. Australia is also a case in point as far as *Puccinia graminis* is concerned, and it is necessary to remember that our seasons are the reverse of those of the Old World. Our cereal crops are generally sown in the autumn months of April and May, or even earlier, and the harvest is

reaped at the end of spring, or beginning of summer in November and December, so that it is the heat and drought of summer, not the cold and wet of winter, which the fungus has to provide against. In fact, the wintering of the uredo is a misnomer here, for it is the excessive dryness and heat which is most injurious.

Bearing this in mind, it is easy to understand that *P. graminis*, although it still continues to produce a certain amount of teleutospores, is perpetuated from season to season by means of uredospores. Self-sown wheat or oats, or even the aftermath of either of these crops cut for hay, is always more or less rusty during the late summer and autumn, the uredospores being freshly produced then through the depth of winter.

The teleutospores of *P. graminis* seem unable to infect the barberry in Australia, and this heteroecious rust would appear to be fast becoming like *Uromyces fabae* reduced to its lowest limits, and reproducing itself only by uredospores. Of course the absence of the barberry would tend to weaken if not destroy the capacity to produce the aecidial stage.

Although the germination of uredospores during winter has already been generally referred to, some definite instances may be given here, and I will select those of *Puccinia graminis*, *P. triticea*, and *P. chrysanthemi* from a number of tests made. The rust appeared on some self-sown wheat, which was growing vigorously during winter (June), and on placing the uredospores of *P. graminis* in a drop of water, they were found to germinate sparsely in seventeen hours, and in twenty-one hours they germinated freely and very generally. At the same time, and from the same wheat plants, uredospores of *P. triticea* were placed under similar conditions, and they also began to germinate within 21 hours, but after several hours longer, only a few were germinating, and not too luxuriously.

The uredospores of *P. chrysanthemi* were also taken from green leaves in May, and they germinated freely, producing long curved germ-tubes.

Thus uredospores taken from growing plants during the winter are capable of germinating, and this proves conclusively that self-sown, or volunteer wheat, on the headlands or elsewhere in the neighbourhood of growing crops is one of the means whereby rust may be continued from season to season. In one case, which I have every reason to believe is quite exceptional, the season's wheat, sown at Wellington, New South Wales, in April, was badly rusted as early as May, but, as a general rule, it is exceedingly difficult, even for the trained observer, to find more than an odd speck of rust in a crop of wheat earlier than the end of September, though there may be plenty on self-sown plants.

There is a conflict of evidence, however, as to the conditions under which germination takes place when the spores are not taken direct from the fresh and growing plant.

Eriksson (Eriksson and Henning¹) found that the uredospores of *P. graminis* lost their capacity for germination during the winter if exposed to the weather, but retained it if kept inside, and even then it gradually disappeared, while Jacky² found that the uredospores of chrysanthemum rust still retained their germinating power, after exposure to the weather for 66 days, from 1st December to 5th February. And Miss Gibson kept spores of the same rust in a dry test-tube in a cool room for 71 days, from March to May, and at the end of that time about one quarter germinated, while a week after none germinated.

The uredospore is primarily a spore for the rapid reproduction of the species. As a rule, it is produced in immense numbers, it is provided with a thin wall, having projections of some sort to act as a holdfast, and it generally infests the leaf or sheath, so that nutrition is not directly

interfered with, as in the case of the teleutospores on the stem. But the uredo may become inured to unfavorable conditions, such as drought or cold, and carry on the life of the species, independent of the teleutospore. This is well seen in *Puccinia poarum*, for in both Europe and America it has been found on the leaves of *Poa pratensis* even after the melting of the snows, and in Australia it occurs on *Poa annua* throughout the winter months, the rust disappearing with the withering of the host, which generally happens early in October. An extreme case seems to have been reached in *P. vexans*, Farl., where, in addition to the ordinary uredo, there is a specialised form to which the special name of amphispore has been given, which is thick-walled, strongly papillate, and only germinates after a period of rest.

It is quite common for the uredo-layer to be attacked by the parasitic fungus, *Darluca filum*, Cast., so much so that it has been found upon 24 per cent. of the species of *Puccinia*. It is somewhat unfortunate that Dr. Cobb⁹ has confounded this parasite with spermogonia, producing spermatia, for in referring to peach rust, he writes:—"I frequently find among the uredospores of a pustule of this rust, small black pycnidia, producing a multitude of two-celled spores, which, when placed in a moist chamber, often bud and multiply after the manner of yeast plants, but which occasionally produce a mycelium. These two-celled bodies have, as I have on several occasions publicly remarked, no slight resemblance to the so-called spermogonia of several species of *Aecidium*." Although spermatia are well-known to be unicellular, yet Carleton² quotes this authority for the statement that ordinary germ-tubes are produced in the germination of spermatia as well as in the other spore-forms. This rust parasite is very commonly distributed, attacking the mycelium and probably checking the development of spores. It occurs on aecidia, uredo, and teleuto-layers, and is recorded on *Uromyces* (9), *Uromycladium* (1), *Puccinia* (22), *Phragmidium* (1), and *Aecidium* (2).

Paraphyses most commonly occur in connexion with the uredosori, and are found in Australian species of *Puccinia*, *Melampsora*, and *Phragmidium* as well as in *Uredo*.

Occasionally they arise in both uredo and teleuto-sori, as in *Puccinia magnusiana* and *P. purpurea*, and sometimes they are variable in their presence as in *Puccinia poarum*, where Plowright found none in Britain, although they are common in Australian specimens. In *Phragmidium subcorticium* not only are the uredosori provided with paraphyses, but likewise the aecidial patches, since they are without a surrounding membrane.

The following are the known Australian species, with paraphyses in their uredosori:—*Puccinia lolii*, *P. magnusiana*, *P. poarum*, *P. pruni*, *P. purpurea*; *Melampsora hypericorum*, *M. lini*; *Phragmidium barnardi*, *P. subcorticium*; *Uredo kuehni*, and *U. spyridii*.

CHAPTER VII.

TELEUTOSPORES.

Teleutospores are very varied in their shape and size, and are on that account often regarded as the characteristic form for distinguishing genera. They may be produced directly from the mycelium of the aecidiospore or uredospore, or indirectly from the teleutospore itself by means of the sporidiola. As the name denotes, it is the last formed, or finishing spore, in the life-history of rusts, although in many instances it is the only spore formed, and there are cases where it has not yet been found. Where it exists alone it may be that the other spore-forms originally existed, but have now come to be dispensed with, and where it does not exist it may be a degenerate type like the other, only it is the teleutospore form which has been dropped. It is a question, however, whether it is not a necessary stage in the life of every rust, and its apparent absence is simply owing to our not having discovered it.

As an example, *Uredo symphyti*, DC. was considered by De Bary to be an independent species, and having lost its other spore-forms to be capable of existing without them, but Bubak² afterwards found the teleutospore in Bohemia, and so it may turn out in other cases.

They arise like the uredospores in smaller or larger spore-beds, often closely crowded together, and usually directly beneath the epidermis which they often rupture. It is seldom that they originate directly beneath the cuticle. The colour of the spore layer is very variable, but generally it is darker than the uredo layer, being dark-brown to blackish, and only rarely reddish.

In the simplest cases teleutospores are unicellular, and originate in a similar manner to the uredospores. The spore-bed, consisting of interlacing and crowded hyphae, gives off erect branches, which become swollen at their free ends, and the finely granular protoplasmic contents are invested by an inner membrane, or endospore, in addition to the outer or epispore, which becomes relatively thick and dark in colour. The teleutospores are generally formed towards the end of the active vegetative period of the host-plant, and are often called winter spores in contrast to the uredo or summer spores. They are specially adapted and equipped for continuing the species over periods of drought, or damp, or cold, or seasons of scarcity. This is seen in the firm outer wall, which is often sculptured in various ways, as well as in the reserve material stored up in the contents. Sydow¹ states that in all Leptopuccinieae, or those only possessing teleutospores which germinate at once, the epispore is perfectly smooth; but there is one exception in Australia—*P. plagianthi*. In other groups the epispore may be smooth, warted, striated, &c.

The portion of the hypha supporting the spore becomes the stalk, or pedicel, by means of which it remains attached to the spore-bed for a longer or shorter period.

In *Endophyllum* the teleutospores originate in chains, and are produced within a peridium similar to aecidia. They would be called aecidiospores, only they produce a four-celled promycelium, which bears promycelial spores. They serve the purpose of summer spores, since they germinate as soon as they are ripe, and the fungus winters by means of its mycelium in the host-plant.

This genus is so anomalous, that it is now coming to be regarded, not as an independent form, but as a biologic genus in connexion with *Puccinia* or *Uromyces*.

Teleutospores may be simple, as in *Uromyces*, or compound as in *Puccinia*. In the newly-constituted Australian genus, *Uromycladium*, the teleutospores are of the *Uromyces* type, but they have the peculiarity of being produced, not solitary at the end of a stalk, but in groups sometimes accompanied by a colourless vesicle. In *Uromyces* and *Uromycladium* there is only one germ-pore, situated at the apex, and the membrane is generally smooth, although it may be warted or striated in *Uromycladium*.

As yet there are known only two Australian genera with compound spores—*Puccinia* and *Phragmidium*, in the one case consisting of two spore-cells, and in the other of three or more in a vertical row.

In *Puccinia* the germ-pore of the upper cell is at the apex, and that of the lower at the side just beneath the transverse partition.

In *Phragmidium*, the number of germ-pores varies in Australian species from one to three in each cell. Dietel¹ has stated that there is only one germ-pore in each cell of *P. barnardi*, but three were invariably found by me in examining a large amount of material.

Paraphyses are not frequently found in teleutospores, probably because teleutospores are generally so well constructed for withstanding variable conditions that they do not require such protection. The best-known example is that of the old species, *Puccinia rubigo-vera*, now split up into several, such as *Puccinia bromina* and *P. triticea*, in which the teleutospores are divided into compartments by the clavate brown paraphyses.—(Note 3, p. 75.) It is worthy of note that the teleutospores are capable of germination in the autumn of the year in which they are produced. There are no other Australian species in which paraphyses are confined to the teleutospores, but they may occur in connexion with the latter as well as with uredospores in *Puccinia magnusiana*, *P. purpurea*, and *Uromyces phyllodiorum*.

The germination of the teleutospores of *Puccinia graminis* in Australia was tested under different conditions, and the most important condition seems to be the season of the year, for they were only known to germinate during the spring months. Badly rusted straw was placed in the cool stores for three months, one portion being kept at a temperature of 4 deg. C., and another at -18 deg. C. A third portion of the same straw was simply kept in the open, and when tested for germination in the spring only the spores exposed to the weather germinated.

Another feature of germination worthy of mention is the way in which it is spread over a period of time, and the spores in the different sori are not all ready at once. There seems to be a succession of ripening, for among a patch of sori only one out of every fifteen or twenty will be found to contain spores capable of germination. This shows the necessity for germinating spores in bulk when tests are being made, for you might happen to select spores which would not germinate, being taken from an unripe sorus. Not only are the spores ready for their work of germination at different times, but the sporidiola are produced in succession, for you never find the promycelium bearing its four spores all at once, at least in *P. graminis*. This is well shown in Plate XV., with the germinating teleutospores of *P. malvacearum*.

CHAPTER VIII.

MESOSPORES AND AMPHISPORES.

In the great majority of Australian Puccinias, 80 per cent. at least, there occur associated with the teleutospores, and quite distinct from the uredospores, unicellular spores which somewhat resemble the two-celled spore in coloration, though generally much paler. It is generally noticeable that wherever the teleutospores are thickened, or apiculate, or prolonged into processes at the apex, or warty on the surface, these spores possess the same characteristics. The conclusion one would naturally draw is that they are teleutospores in the process of making, with the lower cell wanting, just a survival of what is normal in the *Uromyces*. From their partaking of the nature of a middle spore-form between *Uromyces* and *Puccinia*, they are generally called mesospores, and simply represent an imperfectly developed or abortive teleutospore, which may, however, in certain cases perform the functions of a fully-developed teleutospore, although only one-celled.

In the newly-constituted genus *Uromycladium* there are found in considerable numbers among the uredosori, smooth-walled spores smaller than the uredospores, produced singly on basidia and entirely different from the teleutospores, to which the term mesospores has also been applied.

Just as there are two kinds of teleutospores, so there may be two kinds of uredospores, which are represented at present in a few species belonging to *Uromyces* and *Puccinia*, but have not hitherto been found in Australia. This modified uredospore, while agreeing with the normal uredospore in the mode of germination, possesses a thickened epispore, and a more or less persistent pedicel. From its partaking of the characters of both spores, those of the uredospore in its possession of two or more germ-pores, and those of the teleutospore in its germinating only after a period of rest, it has been called an *Amphispore*, by Carleton.

AMPHISPORE.

This peculiar kind of spore was first investigated in connexion with *Puccinia vexans* Farl. This species has a true uredo and teleuto-stage, in addition to a third form of unicellular spore, and the latter was the first to be recognised and recorded. In 1879 it was described as *Uromyces brandegei* by Peck, the unicellular spores being rough with minute warts, and therefore suggestive of *Uromyces*. Then, in 1883, Dr. Farlow¹ found true bilocular teleutospores associated with the supposed *Uromyces*, and named the fungus *Puccinia vexans*, the specific name referring to the perplexing nature of the unicellular spores. As Dr. Farlow writes:—"The perplexing question arises, are the one-celled spores a unilocular form of teleutospores similar to what is known as *P. cesatii*, Schr., or are they the uredospores of this species?" Their true nature was finally settled in 1897, when Carleton succeeded in germinating them, and ultimately they were found to give rise to two germ-tubes, as in the true uredospore which had been discovered the previous year. Now that the three spore-forms are known in this species, it becomes possible to answer the question, in what respect does the amphispore differ from the teleutospore, on the one hand, and the uredospore on the other. It agrees with the uredospore in being unicellular, and having more than one germ-pore, but differs in

being strongly papillate instead of echinulate, thick instead of thin-walled, with persistent pedicel and only germinating after a period of rest. Its essential difference from the teleutospore is its unicellular character and the possession of more than one germ-pore.

Besides the amphispores, mesospores are very numerous in this species, so that there is a *Puccinia* provided with two kinds of uredospores, and two sorts of teleutospores.

Up till recently this was the only instance known of the occurrence of amphispores, but Arthur⁵ has given descriptions and illustrations of nine different species, one of which belongs to the *Uromyces*, in which this form of spore is met with. According to this author, amphispores are mainly developed in arid or semi-arid regions, and represent a resting or winter form of uredospores, being provided with thickened walls to enable them to withstand unfavorable conditions, just like a teleutospore.

MESOSPORES.

In examining the relatively large number of Australian species of *Puccinia* possessing mesospores, one finds that as a rule they are comparatively scarce in point of numbers, and that while a few may resemble the ordinary teleutospore in colouration the majority are paler and altogether with an immature appearance. But there are a few cases, such as *Puccinia heterospora* and *P. simplex*, in which the one-celled spores far outnumber the regular teleutospores, so much so that the latter have been frequently overlooked, and there is every probability that they undergo germination, and are therefore unicellular teleutospores in the fullest sense of the term. In *P. heterospora* there are no uredospores, and the unicellular spores are smooth, and otherwise resemble the teleutospores, while in *P. simplex* the uredospores are spinulose and yellow, and quite distinct from the smooth unicellular spores associated with the teleutospores. Owing to the teleutospores not having been obtained at first, the former has been variously named *Uromyces pulcherrimus*, B. and C., *U. thwaitesii*, B. and Br., and *U. malvacearum*, Speg., and the latter as *Uromyces hordei*, Rost. In fact, these spores have been regarded as a transition stage from the unicellular *Uromyces* to the bicellular *Puccinia* spore. In such cases the one-celled spore functions as a teleutospore, and there would be a certain convenience in distinguishing between the undeveloped and immature spores and those which are fully formed, and in all probability capable of germination, reserving the term mesospore for the one, and unicellular teleutospore for the other. But it is so difficult to draw the line sometimes, and since it is not desirable to multiply names unnecessarily, I will use the term mesospore to designate a unicellular teleutospore form in *Puccinia* and *Uromycladium*, which may either be imperfectly developed and incapable of germination, or fully formed and germinable.

The presence of mesospores in a species would seem to indicate its still close relationship to *Uromyces*, and that its separation from the parent form had not yet proceeded sufficiently far to obliterate every trace of its former connexion.

CHAPTER IX.

SPORIDIOLA OR PROMYCELIAL SPORES.

When the teleutospore germinates, whether at once or after a period of rest, the endospore is protruded through the germ-pore as a germ-tube, and the contained protoplasm passes into it. This germ-tube does not behave like that of the aecidiospore or uredospore, and elongate and branch indefinitely, but it soon ceases to grow in length, and terminates blindly. Hence it has received the special name of promycelium, because it directly produces its spores. The promycelium is soon divided by septa, generally stated as formed from above downwards, but my own observations in regard to *Puccinia malvacearum* show that the median septum is first formed, dividing the promycelium into two, and then each of these subdivides again into two, making in all four cells, from each of which there is a short lateral protuberance which dilates at the end, and becomes a promycelial spore or sporidolum. The two upper cells, as a rule, produce their sporidiola first, then the next, and lastly the lowest; but occasionally the two median cells start first. The name sporidium is often applied to this spore, but since it is already used as equivalent to ascospore, the present name has been proposed by Saccardo.

The sporidiola are easily detached, and, provided with moisture, they can germinate at once, and on the surface of a living leaf the germ-tube can pierce the epidermis, and, growing and branching in the interior, produces a mycelium similar to that derived from the aecidiospore or uredospore. But in the case of grasses the walls of the epidermis often contain much silica, and this may be one of the reasons why aecidia are so scarce in that family. Blackman¹ has shown that there is considerable variation in the length of the promycelium, according to the conditions of growth. Teleutospores, germinating in moist air, produce very short promycelia, and form sporidiola almost immediately, while those germinating in drop cultures, with their germ-tube submerged, grew to a length only limited by the reserve material, but no sporidiola were formed. On reaching the air, however, their formation took place. The free air necessary to their formation is correlated with their distribution by the wind.

If the teleutospore be regarded as the final stage of the cycle, then the sporidolum will be the starting point, and from that there may proceed in regular succession the various spore-forms already enumerated, viz., spermatia, aecidio, uredo, and teleutospores, back to sporidiola again. All these may occur in the same species, and the general course of development is briefly as follows:—From the teleutospore in the spring, sporidiola are formed which develop on a suitable host-plant a mycelium, from which usually on the upper side of the leaf spermogonia are developed, and either on the same side, but generally on the opposite side, aecidia are soon afterwards produced. Infection by the aecidiospores produces the uredo-stage, and these spore-forms often reproduce themselves. The uredo is specially adapted for the rapid spread of the fungus, since from the time of infection up to the formation of new uredospores, only eight to ten days may elapse. Finally, along with the uredo, or in special layers, teleutospores arise which, on germination, produce again the promycelia and sporidiola, and thus complete the course of development. This is the typical mode in which the alternation of spore-forms occurs in many species belonging to different genera, but there is often variation in the order, or even omission of some of the stages. So constantly are aecidial or uredo stages associated

with at least another stage, that when found alone or isolated they are regarded as incomplete, and it is taken for granted that the associated form has yet to be found. In the case of teleutospores, however, there are numerous species which produce them alone, and in such cases, all the other spore-forms are considered to have been suppressed or never formed. And of these surviving teleutospores, in some species they are able to germinate at once, and thus produce successive generations in the course of a year, while in others they can only do so after a winter's rest, and are thus produced only once a year.

In the heteroecious rusts there is no evidence to show that the sporidiola can infect the plant bearing the teleutospores, hence it would appear that *P. graminis* in Australia can only be propagated, as far as spores are concerned, by means of the uredospores. It has not been definitely proved how the sporidiola are distributed, but no doubt the wind is an important factor, and probably also animals assist in the distribution. In connexion with the teleutospores of *Gymnosporangium*, Plowright² says:—"It is probable that the promycelial spores are implanted upon the ovary by insects which had previously visited the *Podisoma* under the delusion that it was a flower, and carried the minute spores with them to the hawthorn." The wind, however, is likely to be the common agency. Since the leaves and stalks bearing the germinating teleutospores often lie upon the ground, it might seem at first sight as if they were not favorably situated for the wind to act upon them, but as they are usually produced in large numbers, sufficient of the sporidiola are likely to be suspended in the air to infect fresh plants when the conditions are suitable.

How long the sporidiola retain their germinating power, and how far they can stand drying up, are questions not yet satisfactorily determined.

CHAPTER X.

PARAPHYSES AND THEIR FUNCTION.

Paraphyses are variously shaped—often hair-like, or capitate unicellular bodies, sometimes accompanying the spores, and are just branches of the hyphae not concerned in, but accessory to, reproduction. These sterile filaments may occur in the spermogonia, where they assume the form of stiff hairs projecting from the mouth, and possibly serve to retain the spermatia until they are carried away and distributed by insects.

But it is in the uredo-layer that they are most commonly met with, and there they are of various shapes. They are recorded in Australian species of *Puccinia*, *Phragmidium*, *Melampsora*, and in *Uromyces phyllodiorum*, and along with other characters may be useful in the discrimination of species, as in *Puccinia magnusiana*, Koern., where they at once distinguish it from the other species occurring on *Phragmites communis*. They usually surround and arch over the spore-bed, and the apex is often swollen in a globose or clavate manner.

Their principal function is probably the same as that of the hairs in some grasses and other plants—to protect the spores when exposed by the rupture of the cuticle against excessive evaporation and consequent drying up during the day, and to moderate the temperature in the cold nights.

In the genus *Melampsora* and some species of *Puccinia* and *Uredo*, e.g., the uredo of *P. poarum*, *P. magnusiana*, and *U. spyridii* growing on hosts in damp situations or along rivers and in moist valleys, the paraphyses have always swollen capitate heads, and their function is suggested by their structure and position. The wall is much thickened, so as to leave a very small cavity in the head, and in the stalk it may become so thick as completely to obliterate the cavity and thus render it solid. The thickened head has a great capacity for retaining moisture, and since they are crowded together and over-lap the spores, they will prevent them from getting soaked and at the same time protect them against excessive evaporation, which would have a drying effect according to Dietel⁹.

Their great function is as protective organs when the spores are exposed by the rupture of the cuticle, and Plowright compares them with the pseudoperidial cells of the aecidiospores. He has made observations on the paraphyses of certain species, and found that their presence greatly depends upon some special condition of the fungus. "I find them constantly present with the uredospores of *Puccinia perplexans*, Plow., when these have arisen, not directly, but rather at a considerable distance from the aecidiospores. On the other hand, when the uredo arises directly from the aecidiospore, they are hardly present at all; this looks very much as if they were an indication of exhaustion of vital energy on the part of the fungus, which was combated by protective efforts on the part of the parasite in conserving those spores which it does produce, but when full of vigour and fresh from the aecidiospore it is less careful of its spores. When it begins to feel the effect of exhaustion, and is unable to develop such energetic spores, it takes more care of those which are produced."

Or it may be that when the fungus begins to feel exhausted, it is unable to develop so many spores, and barren protective filaments take the place of those which would normally produce spores. If the paraphyses serve to prevent excessive evaporation, then it would follow that in the early spring, when there is little need for protection on this account, there would be little use for them; but towards the summer, when the air is

dry, they would be required in much larger numbers. The presence or absence of paraphyses at different periods of the year seems to have been only definitely observed in this one species, but there are other instances which may possibly belong to the same category. Thus Winter describes *Uromyces dactylidis* Otth. with capitate thickened paraphyses, and Plowright distinctly states that they are absent, and this discrepancy may arise from the observations having been made at different seasons of the year. Again, *Puccinia poarum* Niels. is without paraphyses, according to Plowright; but Schroeter found them in Germany, and I have found numerous long ones in Australia. In *P. magnusiana* Koern. the clavate paraphyses are of a dark smoky brown colour in the head and hyaline in the stalk. They only occur at the margin of the uredo-layer, and there is a slight indentation on the inner side, so that the head bends over. In *Phragmidium subcorticium* the tubular, thin walled paraphyses are always marginal both in the uredo- and aecidio-spore generation, and are curved inwards.

Another function has been suggested by Magnus⁶ in addition to that of protection. In several species of *Coleosporium* he found that the paraphyses served both for protection and for raising and bursting the epidermis so as to make room for the growing spores.

To a certain extent paraphyses may assist in raising the cuticle and hastening its rupture; but there are plenty of species which rupture the cuticle in the absence of paraphyses, and in the case of paraphyses associated with teleutospores, they rather appear to prevent the cuticle breaking away until it decays.

CHAPTER XI.

ORIGIN OF THE PRINCIPAL SPORE-FORMS.

The most characteristic feature of the Uredineae and that which renders them specially interesting is the variety of spore-forms which they produce. But while on the one hand there is a regular succession of spore-forms, on the other the number may be reduced even to a single kind, and the question arises in such cases whether the missing spore-forms have dropped out of the course of development, or whether they have never been formed. Since, as we shall see, there is every reason to believe that the various spores originated from a primitive form, the natural conclusion would be that where they do not occur they have not yet been developed, yet there are cases where intermediate forms may have been suppressed, judging by what obtains in closely allied species.

In all rusts whose complete development is known there is one kind of spore which is invariably present, and which serves to distinguish the various genera, and that is the teleutospore. But the teleutospore on germination gives rise to another kind of spore, the sporidium, which may be regarded as the starting-point of the life-cycle, just as the teleutospore is the last-formed or finishing spore.

The simplest form of spore, using this term in its widest sense, was at first developed from any joint of the exposed hyphal filament, but ultimately as the differentiation between the vegetative and reproductive portions of the fungus became more marked, the point of origin was restricted to a definite spot of an upright hypha—towards the apex. By a process of abstriction, the end of the hypha was rounded off and detached by simple contraction without the formation of any septum. These might either be produced solitary or several formed in succession, constituting a chain. (Fig. 7 a, b.)

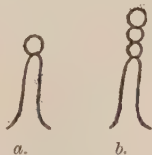


FIG. 7.

The spore might also originate by budding, as in the case of the Yeasts, where a small protuberance quickly grows to its full size, becomes rounded off, and detaches itself. In this process of budding the protuberance often narrows itself at the point of attachment into a slender stalk, whereby the connexion with the parent cell is maintained until the spore is fully formed. (Fig. 8.)



FIG. 8.

This short delicate stalk proceeding from the parent cell is known as a *sterigma*, and either by abstriction or budding the origin of the various spore-forms may be explained.

SPORIDIOLUM.

The sporidiolum was probably the earliest form of rust spore, and represents the transition from the saprophytic to the parasitic mode of life. If we start from undoubted saprophytes, the passage from the one to the other will be made clear. It was not only necessary for the spread of these fungi that the spores should germinate rapidly, but that they should be produced in sufficient numbers, and so the basidium, or parent cell, had either to produce more than one spore or divide up into several cells. In accordance with this, in one type, the one-celled basidium produces mostly four spores (Fig. 9); in another type the basidium divides usually into



FIG. 9.

four cells, each cell producing a spore. The latter type is well seen in the Auriculariaceae where in such a genus as *Saccoblastia* the basidia are transversely septate, and each cell bears a sterigma with its spore (Fig. 10).



FIG. 10.

Turning now to a parasitic genus such as *Coleosporium*, there is a close resemblance in the mode of formation of spores. The body called the teleutospore is found to consist of four cells placed one above the other, and each cell gives rise to a sterigma, with a sporidiolum at the end of it (Fig. 11). This is something very different from the typical teleutospore,



FIG. 11.

in which each cell produces, not an ordinary undivided germ-tube, but a *promycelium* divided into four cells, each of which bears a sterigma with a sporidiolum. The so-called teleutospore of *Coleosporium* is evidently the representative of the septate basidium in the Auriculariaceae, although it is generally considered to be an exceptional form of teleutospore, which occurs in other genera of Rusts as well, such as *Ochropsora*, *Trichopsora*, and *Chrysopsora*. If the basidia in one of the saprophytic Auriculariaceae, such as *Saccoblastia ovispora* Moell., are compared with those of the parasitic *Coleosporium senecionis*, there is seen to be complete agreement in the structure.

The sporidiolum was thus at first the product of a basidium arising from a mycelium, but there was nothing specially characteristic in this, nor any advance upon the mode of reproduction in a saprophytic fungus. That which constituted the Rusts a distinct class, and separated them from their nearest allies, was the development of a new kind of spore, the teleutospore, which produced directly on germination, without the intervention of any mycelium, a basidium bearing sporidiola. In the one case the sporidiola were derived from a basidium borne by a mycelium nourished on dead or decaying matter; in the other the basidium, or so-called promycelium, was the direct product of a living spore. This spore is the special feature of this group of parasitic fungi, and will now be considered.

TELEUTOSPORE.

In the sporidiolum the fungus is provided with a spore capable of germinating at once and reproducing the original form, but a parasitic fungus requires further to accommodate itself to the varying seasons of growth of the host-plant, and so a spore that could persist during the winter while vegetative activity was practically suspended, became a necessity. Hence the teleutospore, or typical resting-spore, was introduced into the cycle to provide a thick-walled form, which could withstand the vicissitudes of climate and be ready to germinate when spring, with its revival of growth, returned. While some teleutospores are capable of immediate germination, the great majority undergo a period of rest, and a thickening of the wall is associated with this condition.

While the sporidiolum was thus probably the earliest-formed rust spore, it did not meet all the requirements of the new mode of life, and thus the teleutospore became a necessity for parasitic life, a condition dependent on the changes of a living organism. The great feature of a teleutospore is the mode of germination and its product, and perhaps the simplest form is represented by that of *Barclayella* Diet., in which there are several cells in a row, and each cell produces a promycelium or septate germ-tube. The peculiarity and primitiveness of this promycelium lies in the fact that, instead of dividing transversely and each cell giving rise to a sporidiolum, the promycelium itself breaks up into four divisions, each of which becomes a sporidiolum (Fig. 12).



FIG. 12.

The only species belonging to this genus occurs on a Conifer (*Picea morinda* Link) in the Himalayas, and neither uredospores nor aecidiospores are known. It produces the most primitive form of teleutospore, and the germ-tube produced from each cell breaks up directly into sporidiola, which again reproduce the fungus. This is an evident contrivance for multiplying the spore-form (teleutospore) and providing a fresh start with a sporidiolum, minute, light, and easily transported by the wind.

The next advance in the development of the teleutospore may be seen in an interesting genus, just described by Arthur⁶, to which he has given the name of *Baeodromus*. It occurs on *Senecio*, and resembles *Coleosporium*

senecionis so much in general appearance, that it was at first regarded as that species, but the teleutospore produces a regular promycelium, with sterigmata and sporidiola, so that it well illustrates the transition from the basidia bearing sterigmata in *Coleosporium* to the typical teleutospore with a promycelium. The teleutospores are united into a solid mass, and are arranged in chains consisting of 5-8 cells in a series, and while Arthur considers each cell as a teleutospore, the chain of cells might be regarded as a multicellular teleutospore. The spores germinate immediately, and the promycelia, together with the four globose sporidiola, have bright orange contents (Fig. 13). Closely related to this form is *Chrysomyxa*, in

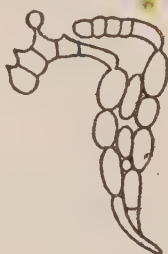


FIG. 13.

which the teleutospore consists of a series of cells, and on germination produces promycelia of several cells, each of which bears a sterigma with sporidium. In *Melampsora* the unicellular teleutospores form a compact mass, producing promycelia of the typical form, and thus a teleutospore may either consist of a simple cell or a series of superposed cells.

A teleutospore is thus a unicellular or multicellular spore, producing on germination a promycelium, which either directly breaks up into usually four sporidiola or divides into four cells, each of which produces a sporidium at the apex of a sterigma. There is one exception to this in the genus *Endophyllum*, in which the promycelium is the product of an aecidiospore, but this may be regarded as a case where the function of a teleutospore has been transferred to a derivative form, the aecidiospore.

UREDOSPORE.

The view that the uredospore is probably derived from the teleutospore is favoured by the variability of the latter in many species, and the gradations which are found to occur. At first sight the differences between the uredo and teleutospore seem so great as to be insurmountable, but there are distinct transitional forms from the one to the other. The membrane of the typical uredospore is covered with spines, and this is an evident adaptation for the spore which germinates immediately and is short-lived, and the characteristic spines serve to attach it to the surface of the host-plant in order that germination may be successfully accomplished. Magnus², who inclines to the view that the uredospores have developed out of teleutospores, shows that in *Uromyces scutellatus* (Schrank), Lev., a gradation can be traced between the reticulate or tuberculate membrane of the teleutospore and the finely tuberculate or echinulate membrane of the uredospore.

As to the thinning of the wall, there is also every gradation to be met with from the thick brown membrane to the thin, almost colourless one. The passage from the one to the other possibly took place through such a form as the amphispore, a modified uredospore still capable of undergoing a period of rest, and in which the wall still retains its thickness, but there are several germ-pores. They may resemble the uredospores in shape,

echinulation, and germ-pores, but still they are resting-spores with thickened walls. Fischer¹ has also illustrated the transition in a series of two-celled teleutospores of *Gymnosporangium confusum*, which have all germinated, and which show a dense thick membrane at one end of the series and an excessively fine one at the other. And Dietel³ has pointed out that the occurrence of thick and thin-walled spores in species of *Gymnosporangium* is quite common, and that it is a character of the genus that the teleutospores formed in the interior of the gelatinous mass are thin-walled, while the external ones are thick-walled. The gelatinous substance is formed from the gelatinous walls of the stalks of the teleutospore, and readily absorbs the rain-water and thus facilitates the germination of the spore. Another important difference between the uredospore and teleutospore of *Uromyces* is that while the latter only possesses one germ-pore, the former has two or more often arranged as an equatorial band. But here again Magnus shows in species such as *U. proëminens* (DC.) Pass. and *U. tuberculatus*, Eckl., every transition from the normal teleutospore with apical germ-pore, through one with the germ-pore becoming somewhat lateral, then with apical and lateral germ-pores, until the typical uredospore is reached with a band of germ-pores confined to the equator, or several scattered.

In *Puccinia podolepidis* there is often a germ-pore on either side of the upper cell of the teleutospore, as shown in Pl. XXIX., Fig. 257. A third and very important difference between the uredospore and teleutospore lies in the mode of germination. Not only does the uredospore germinate immediately on maturity, but it puts forth a germ-tube which penetrates directly into the host-plant, while the teleutospore often undergoes a period of rest and does not directly reproduce the fungus, but gives rise to a promycelium bearing promycelial spores, which germinate and enter a host-plant. It would appear at first sight as if this mode of germination created a distinct barrier between the two kinds of spore, but when closely looked into there is considerable variation in the germination of the teleutospore, and under certain conditions it may forego the production of intermediate spores.

Kienitz-Gerloff¹ has shown that in *Gymnosporangium clavariaeforme*, Jacq., the thin-walled teleutospores do not produce a promycelium and promycelial spores, but simply a germ-tube like that of a uredospore. And Dietel³ has further shown that both thick and thin-walled spores may sometimes germinate in this way, and thus serve the purpose of the uredospore occurring in other genera. Fischer¹ has also pointed out the influence of external conditions on the mode of germination, the sporidiola only being formed in air, while in water or in the interior of the gelatinous mass surrounding the spores, an elongated germ-tube is formed. This has been corroborated by Blackman¹, who found that the germ-tube is incapable of sporidiola formation when submerged, and that under these conditions it continues to grow in length until its reserve material is exhausted. He also found that when germ-tubes of *Phragmidium rubi* were produced in water, they might become divided into four cells, as if about to bear sporidiola, but these cells, instead of following the ordinary course, rounded themselves off and separated. Fischer observed in *Gymnosporangium confusum* that the cells of the promycelium separated before forming sterigmata and promycelial spores, but Blackman, in a MS. note to his paper¹, kindly sent to me, says: "These are the cells of the promycelium which are rounding themselves off and becoming directly sporidia." So that there appears to be every gradation in the germination of the teleutospore, from the production of a simple germ-tube to the division of the germ-tube into cells which germinate, and finally the promycelium bearing promycelial

spores. It is worthy of mention that Magnus² has repeatedly observed that when the teleutospores of *Puccinia graminis* were germinated in water they produced an undivided germ-tube just like that of a uredospore, but he could not satisfactorily settle the question, if this germ-tube could directly penetrate the host-plant.

The passage from a thick to a thin wall, from one to a number of germ-pores, and from a typical promycelium to an ordinary germ-tube, has been shown, and it all tends to support the view that the uredospore may have been derived from a teleutospore.

This peculiar germination of the teleutospore, in which each promycelium breaks up into three or four detached cells, apparently representing sporidiola, had been observed by Barclay³ as early as 1891, in *Puccinia prainiana*, Barcl., and *Uromyces solidaginis*, Niessl. He considered this abnormal mode of germination to be due to the restricted supply of air obtained by the spores in a hanging drop of water, for, when allowed to germinate in a watch-glass of water, with freer access of air, the germination was normal.

But this rounding off of the promycelial cells may be due to the influence of micro-organisms in the water. So far as our own observations go, certain organisms are always present in great abundance when this rounding off of the cells occurs. A similar phenomenon is observed in connexion with the hyphae of numerous fungi growing in water or fluids invaded by bacteria.

In another respect the uredospores show a distinct transition. In a well-developed spore-layer they always precede the associated teleutospores, but in *Uromyces scutellatus*, as Magnus² has repeatedly observed, in different years they may appear simultaneously.

The uredospores may thus be regarded as having been derived from the teleutospores, or from a mycelium common to both, and the question naturally arises as to the origin of the aecidiospores.

AECIDIOSPORES.

Aecidiospores and uredospores are often so much alike that they are mistaken for each other, and sometimes there is a difference of opinion as to whether a spore-form should be regarded as one or the other, as in *Triphragmium ulmariae*; but, generally speaking, aecidiospores are produced in chains, and uredospores singly on evident pedicels. In *Coleosporium* and *Chrysomyxa*, however, the uredospores are developed in chains as well as the aecidiospores, and this renders necessary the further distinction that the aecidiospore always precedes the uredospore in point of time.

In *Phragmidium subcorticium*, for instance, the aecidiospores were not recognised at first as distinct from the uredospores, but although the individual spores resemble each other closely, the fact that one is produced in chains and the other not, distinguishes them. When aecidiospores are produced without any special envelope or pseudo-peridium, as it is called, it is distinguished from the *Aecidium* proper as a *Caeoma*, and there is every gradation from naked to covered aecidia. In *Chrysomyxa* the uredo is regarded as a caeoma-form by Raciborski but in *Phragmidium* the aecidiospores are protected by a dense layer of paraphyses, which surround them, and thus take the place of a peridium. *Triphragmium ulmariae* (Schum.) Link, has what are called primary and secondary uredospores, although the former are described by De Toni as aecidiospores, but they are not produced in chains. Winter regards them as biological representatives of the aecidium, and Drs. Milesi and Traverso¹ speak of them as epiteospores, to distinguish them from caeomospores, which are arranged in chains. There

is no essential point of distinction between aecidiospores and uredospores, for though the former are always formed in chains, yet undoubted uredospores may also be thus produced. Hence there is no valid distinction between the two, even to the matter of nuclei, for both are binucleate.

The aecidiospore is just like the uredospore, thin-walled, and adapted for immediate germination; but since it is essentially a spring form, and required to keep pace with the rapid growth which then takes place, it is not formed solitary upon a stalk, but tier upon tier, to make abundant provision for the coming season. It is usually uredospores and aecidiospores which are confounded together, but there is one case at least in which the aecidiospore partakes of the character of a teleutospore. In *Endophyllum* the spores are produced in chains, and within a pseudo-peridium just like normal aecidia, but instead of germinating in the usual way, each one produces a four-celled promycelium, giving rise to promycelial spores just like a teleutospore. They may either be described as aecidiospores which produce promycelia or as teleutospores resembling aecidiospores. This genus is not now generally regarded as independent, but as related biologically to *Uromyces* or *Puccinia*, and it will probably turn out to be a case where an aecidiospore still retains marks of its early origin from a teleutospore in its mode of germination. (Note 4, p. 75.)

SPERMOGONIA AND SPERMATIA.

If the aecidiospores were the result of a sexual process, as is sometimes maintained, then of course they could not be derived from teleutospores, and the mere fact that I have attempted to account for their origin from this source shows that some other explanation must be forthcoming for the so-called male sexual organs—spermogonia and spermatia. In lichen-fungi such as a *Collema* a true process of conjugation occurs, and the male organ or spermogonium, with its contained spermatia, resembles very closely in structure the similarly named bodies in the rusts. It was Tulasne who originally discovered these bodies in 1851, and who suggested their sexual nature, which he based partly on the fact that the spermatia were not known then to germinate, and partly that they usually preceded or accompanied the bodies they were supposed to fertilize, viz., the aecidia.

Great attention has, therefore, been paid to the spermatia, in order to discover if they were capable of germination, and it has been found that in a nutritive solution they grow and bud after the manner of yeast, but no definite mycelium has been produced.

It is generally stated that the spermogonia either precede or accompany the aecidia, but they may occur with all the spore forms, according to the one which is first produced. Aecidia usually follow the germination of the sporidiola, and therefore spermogonia accompany them most frequently; but if the first formed spore is the uredo, as in *Triphragmium ulmariae*, *Uromycladium maritimum*, and *Puccinia obtegens* (Lk.) Tul., then they accompany it, and if a teleutospore as in *P. liliacearum*, Duby. or *Uromycladium tep-³perianum*, the spermogonia are associated with it. But Arthur³ states the case more generally when he remarks that "every one who has made cultures of the rusts knows that in about a week after sowing the germinating teleutospores there will appear spermogonia, without any regard to the kind of spore that is to follow." There are even instances where the spermogonium has entirely disappeared, as in *Puccinia malvacearum*, Mont. It is acknowledged by those who have given special attention to the subject that the spermogonium is an isolated organ, of uncertain origin and function, and that the balance of evidence is against its being a sexual organ. The spermogonium is seldom absent from the life-cycle, and yet it takes no direct

part in the reproduction of the fungus. Its meaning seems to have been lost, but its origin from the sporidiolum seems to indicate that it may be the survival of the conidial reproduction of the sporidiolum.

Unless in cases where the mycelium is perennial, the sporidiolum germinates and produces a mycelium, which gives rise to the spermogonium. The same mycelium may either produce aecidia, as is usually the case, or in the absence of aecidia, uredospores; or, if both are absent, the teleutospores, as in *Uromykladium tepperianum*. The spermogonia are never produced alone, but always precede or accompany some other spore form, for the very good reason that they are incapable of reproducing the fungus. When the spermogonium is about to be formed, the hyphae become interwoven, and form a tangled mass in the sub-epidermal tissues. From this numerous delicate branches are given off, which are directed towards the epidermis. These branches converge towards a central point and form a somewhat round or piriform body, which is only covered by the cuticle at the top. The periphery of this body consists of a dense felted mass of sterile hyphae, quite unlike the peridium of the aecidia, which are likewise always deeper-seated than the spermogonia. The so-called spermatia arise inside the spermogonia in short chains by a process of abstriction at the end of fertile converging hyphae, and are held together by a gelatinous substance which contains a certain amount of saccharine matter. (Pl. XXIII., Fig. 203.)

The probable origin of this puzzling body may thus be accounted for: We may suppose that the sporidiola were spread principally by wind and rain, and at first only produced teleutospores. But in order to secure the intervention of insects which were now becoming adapted to the floral world, a new kind of reproductive body was developed, and the spermatia abstricted in chains were produced in spermogonia with a sweet bait to attract insects. But when the teleutospores gradually developed uredospores and the same mycelium could produce the three spore-forms—spermatia, teleuto, and uredo spores—then the former became less and less necessary. When finally the aecidiospores were developed, produced in great abundance, and also in chains, then the competition was too keen, and the necessity for spermatia practically ceased to exist, since the germinating sporidiola could produce the aecidia, and the germinating aecidia both the uredospores and the teleutospores. Besides, the bright colour of the uredo and aecidio spores may serve to attract insects for purposes of distribution, and so they were able completely to replace the spermatia. Finally, the spermatia lost their capacity for germination, and now the spermogonium is an organ which has survived its function, and only remains as a landmark to show what once had been the prevailing type of reproductive body adapted for distribution by insect life.

We can thus picture to ourselves the progenitors of the rusts leading a saprophytic existence and gradually adapting themselves to the new mode of life when the parasitic habit was developed and a modification in the spore-forms occurred. The evidence of this great change is shown in the development of a spore primarily adapted for undergoing a period of rest, and from the stored-up material directly producing a basidium with sporidiola, instead of being preceded by a more or less scattered mycelium.

The peculiarity of the teleutospore lies in the fact that it is an independent body capable of giving rise directly and without any further food supply to fresh spores by the production of a septate germ-tube, which develops secondary spores unlike the original, being smaller, thin-walled, and ready to germinate at once on the damp surface of a living leaf.

In course of time the teleutospores became differentiated into forms adapted for extremes of temperature and resting, as well as other forms

adapted for favorable conditions and rapid dissemination of the species—uredospores. The third form of spore would probably be developed later in point of time. The aecidiospores were at first just like the uredospores, only produced tier upon tier as required, and the great purpose served by all these different kinds of spores would be to provide a continuous succession of spore-forms—*aecidiospores* in the early spring, when the first rush of growth commences; then *uredospores* during spring and summer, when steady growth is maintained; and finally *teleutospores* towards the autumn, capable of remaining dormant during the winter and starting the whole series again in the spring by means of promycelial spores.

The so-called spermogonium does not enter functionally into the present cycle, being a relic of the past and a survival of the time when insects were being catered for by the rust-fungi in order to aid in the distribution of their spores; but the development of such numerous and varied brightly coloured spore-forms has rendered unnecessary this special form of fructification.

VARIABILITY OF TELEUTOSPORES.

When the teleutospores in the different genera of rusts are carefully examined, it is often found that there is not only considerable variation in the size and shape, but the seemingly constant character of the number of cells is departed from. It is not always convenient to record this in a systematic description, and I have selected a few species to give an indication of what is not at all uncommon throughout the Uredineae (Pl. XL.). This variability not only shows how the uredospore in each genus might have been derived from the teleutospore, but also how the multicellular form of spore might have originated from the unicellular. Starting with the genus *Uromyces*, there is no difficulty in showing how the bicellular spore of *Puccinia* may have originated as in *Uromyces orchidearum*, *U. tricorynes*, and *U. vesiculosus* (Pls. XVI., XVIII., XL.) Then in the genus *Puccinia* there is not only the unicellular teleutospore or mesospore to indicate its probable origin from the *Uromyces*, but in addition to the two-celled spore there are three and four celled spores, in which the cells are arranged in a manner suggestive of various genera. The different forms seen in a single preparation of *P. dichondrae* Mont. are shown in Plate XL., and there are at least seven forms met with—(1) the unicellular spore, or mesospore, generally with thickened apex, and resembling the uppermost cell of the next form; (2) the typical bicellular teleutospore; (3) the three or four-celled spore, with the cells arranged in linear series, superposed more or less regularly, and after the *Phragmidium* type; (4) a three-celled spore, consisting of one basal cell supporting two longitudinally divided on top, and resembling the *Triphragmium* type; (5) a three-celled spore, consisting of two basal cells longitudinally divided and a single cell on top, as in *Hapalophragmium*; (6) a four-celled spore with the two lower superimposed, and the two upper longitudinally divided; (7) a four-celled ellipsoid spore longitudinally and transversely divided, as in *Sphaerophragmium*. It is worthy of note that there are no uredospores in *P. dichondrae*, but, even in *P. ludwigii*, where uredospores are present, there is also a considerable amount of variation. A two-celled spore is met with here, having the septum longitudinal instead of transverse, and the pedicel in a line with it, as in *Diorchidium*. *P. graminis* and *P. triticina* also show a considerable amount of variation, if large quantities of material are examined. Other genera exhibit variation of a similar kind, and there is a basis here provided for natural selection to work upon, and evolve the various forms which are used to characterize the different genera of the Uredines.

CHAPTER XII.

RUSTS IN THEIR RELATION TO OTHER FUNGI.

The Fungi, as a class, are generally regarded as having descended from the Algae, but since the latter possess the green colouring matter or chlorophyll which enables them in the presence of sunlight to abstract carbon from the carbon dioxide of the air, they do not seem to be the most primitive forms. But the fission-fungi, such as the nitrifying bacteria occurring in the soil, are able, in the absence of light and chlorophyll, to split up carbon dioxide and obtain the necessary carbon likewise from inorganic material, so that the first forms of life to appear upon the earth could thus obtain their nourishment without organic compounds at all. The development of the chlorophyll would thus occur at a later period, and the fungi proper, as well as the algae, may have had a common origin from these primitive bacteria, instead of the one being a degenerate form of the other.

Following the fate of the fungi, with which we are more immediately concerned, their course of development ran parallel with that of the algae, so much so that they have been regarded as degenerate algae or algae without chlorophyll. This primitive stock resembling the algae so closely is known as Phycomycetes, and from this divergence has taken place in two directions, the offshoots representing two main divisions of fungi. In the one case the Ascomycetes or fungi producing spores in delicate sacs or asci, and in the other, the Basidiomycetes or fungi producing naked spores on large terminal cells known as basidia. To this latter division belong the Uredines or rusts, since they produce basidia which are transversely divided, and bear naked spores; but they occupy a low position as compared with the higher Basidiomycetes, including the mushrooms and toadstools. In the Ustilagines or smuts closely related to the rusts, the basidia are not as yet definitely fixed, since the spores are produced at any part and new ones are developed when the old ones fall away, which is not the case in the rusts.

The following arrangement will show the position of the rusts in this scheme of classification:—

Fungi.

Phycomycetes (Alga-like Fungi)	{	Ascomycetes	{	Hemibasidii (Smuts)
		Basidiomycetes		Protobasidii (Rusts)
				Holobasidii (Mushrooms, &c.)

Starting from the Phycomycetes or alga-like fungi, there is one division of them which bears both sporangia and naked spores, and another in which the sporangia may be wanting. The former would give rise to the Ascomycetes, and the latter to the Basidiomycetes, which exclusively reproduce themselves by naked spores.

The smuts are generally regarded as stepping-stones from the Phycomycetes towards the rusts, which have become more closely identified with the true Basidiomycetes, where the basidia are entire and not divided.

The above gives a very general idea of the position of the rusts among the fungi, and indicates briefly, without entering into detail, how they may have originated.

The parasitic habit of the rusts will account for several features in their life-history as well as in their structure. Being dependent on other

plants for their sustenance, they must accommodate themselves to their surroundings, and so they may pass through different stages, sometimes on the same plant, or on different plants. These various stages represented by different reproductive bodies, enable the rust to produce spores which can germinate at once if food supplies are available, or others which can rest if need be. The change of host is an evident advantage, not only from the point of view of a change of diet, but it may thus pass from one plant that dies down to another that is perennial. It may even become perennial itself in the underground parts of some plants, and then it vegetates, only producing rarely the reproductive bodies which would be formed under normal conditions.

CHAPTER XIII.

INDIGENOUS AND INTRODUCED SPECIES.

In a large continent like Australia, where so many plants have been introduced, both for economic and ornamental purposes, it is not always easy to determine what rust-fungi are native to the country, and those that have been introduced on imported plants. A plant may be indigenous, and yet the rust upon it may have been derived from an allied species, as in the case of *P. thuemeni* on native celery (*Apium prostratum*) which was possibly introduced with cultivated celery (*Apium graveolens*), *P. menthae* on native mint introduced upon cultivated mint, and *Melampsora lini*, on native and cultivated flax. On the other hand, species of rust occur on well-known imported plants, such as the daisy, groundsel, and marigold, which are not recorded elsewhere, and the natural conclusion is that they are indigenous, or have been overlooked elsewhere. It is only in rare cases that the first introduction of any species of fungus is observed and accurately determined, so that we must fall back upon some well recognised principle to settle whether a rust is indigenous or not. Where a new species is found on a native plant, it may be taken for granted that it is indigenous, and even where the species is already known, but the plant has a wide distribution, such as *Phragmites communis*, then there is no reason to doubt that a rust upon it, such as *Puccinia magnusiana* is also indigenous. The great majority of the rusts here recorded are, of course, native, and it will only be necessary to single out those which have, in all probability, been imported from other countries.

The following species may be regarded as having been introduced on the grounds indicated* :—

- Puccinia anthoxanthi* Fckl. on *Anthoxanthum odoratum* (1896).
- P. arenariae* (Schum.), Schroet. on *Stellaria media* (1896).
- P. beckmanniae* n. sp. on *Beckmannia erucaeformis* (1904).
- P. chrysanthemi* Roze, on *Chrysanthemum indicum* (1904).
- P. cichorii* (DC.) Bell., on *Cichorium intybus* (1885).
- P. cyani* (Schleich.) Pass. on *Centaurea cyanus* (1904).
- P. festucae* Plowr. on *Festuca pratensis* (1903).
- P. graminis* Pers. on Wheat, &c. (1825).
- P. helianthi* Schwein. on *Helianthus annuus* (1887).
- P. hypochoeridis* Oud. on *Hypochoeris radicata* (1889).
- P. impatientis* (Schw.) Arthur, on *Elymus condensatus* (1903).
- P. lolii* Niels. on *Lolium perenne* (1896).
- P. malvacearum* Mont. on *Malva*, &c. (1857).
- P. maydis* Bereng. on Maize (1880).
- P. menthae* Pers. on *Mentha laxiflora* (1884).
- P. poarum* Niels. on *Poa annua* (1890).
- P. prenanthis* (Pers.), Lindr. on *Lactuca* sp. (1892).
- P. pruni* Pers. on *Prunus* sp. (1883).
- P. purpurea* Cooke, on *Sorghum halepense* and *S. vulgare* (1892).
- P. simplex* (Koern.), Eriks. and Henn. on Barley (1902).
- P. thuemeni* (Thuem.) McAlp. on *Apium graveolens* and *A. prostratum* (1892).
- P. triticina* Eriks. on Wheat (probably 1825).
- Uromyces appendiculatus* (Pers.). Link. on *Vigna catjang* (1905).
- U. betae* (Pers.), Kuehn, on *Beta vulgaris* (1878).

* The year in brackets indicates when first recorded for or observed in Australia.

- U. caryophyllinus* (Schrank), Schroet. on Carnations (1896).
U. fabae (Pers.), De By. on Beans (1898).
U. polygoni (Pers.), Fckl. on *Polygonum aviculare* (1896).
U. trifolii Alb. and Schw. on *Trifolium repens* (1892).
Phragmidium subcorticium (Schrank), Wint. on *Rosa* sp. (1892).
Melampsora lini (Pers.), Tul. on *Linum usitatissimum* and *L. marginale* (1889).
Uredo kuehnii Krueg. on Sugar-cane (1893).

It would be interesting to trace from what quarter these species found their way into Australia, but from the very nature of the case, it is impossible to tell exactly, except in a few instances, and one can only make shrewd guesses as to the rest. The inquiry would mainly resolve itself into the importation of the host-plants, either by cuttings or seed, and the seed of such weeds as chick-weed (*Stellaria media*) and knot-weed (*Polygonum aviculare*) might easily be carried in straw packing or in hay.

Mr. Ellery, F.R.S., late Government Astronomer, has pointed out that the scarlet pimpernel (*Anagallis arvensis*) was first observed as an introduced weed in the Observatory grounds, and he informs me that as many English and African plants appeared there at different times after unpacking cases from the different countries, he came to the conclusion that seeds from the packing were the source. Both uredo and teleutospores of *Puccinia graminis* have been found on wheat straw envelopes on bottles of wine imported from France.—(Note 5, p. 75.)

In the case of the cereals and grasses, the rust spores would probably be brought with the seed, and this is certainly true as regards *Puccinia beckmanniae*. The seed of *Beckmannia erucaeformis* Host. was forwarded to me in 1903 by the United States Department of Agriculture, and on growing it at Leongatha, the rust was very copiously developed in February and March, 1904. E. D. Holway informs me that it is known in Minnesota, U.S.A., although it has not hitherto been published.

The seed of *Elymus condensatus* was also sent from America in 1903, and the rust (*Puccinia impatientis*) appeared upon the plants in December of the same year.

The latest addition to our imported rust-fungi is that of *Puccinia chrysanthemi*, and it was observed for the first time in New South Wales in 1904. Cuttings had been imported from England, and thus the rust was carried; but it has not as yet spread very much. Only the uredospores occur here as in England, and I was able to germinate them freely in tap-water towards the end of May. It is by means of this trade in cuttings that the rust is likely to be spread, unless proper precautions are taken. The history of its distribution is rather interesting. It is probably indigenous to Japan, and in 1895 it first appeared in England, then in France in 1897, and about the same time in Denmark and Germany. In 1900 it reached America and Switzerland, and now, in 1904, or earlier, it has come to Australia, probably by way of England. It was also recorded for New Zealand in 1904.

The mallow rust (*Puccinia malvacearum*) has been known in Australia since 1857, when it was found in the neighbourhood of Melbourne, and now it is one of the commonest rusts we have. It is remarkable for the rapidity of its spread, nearly over the whole world, since it was first described in 1852 from Chili, where it is indigenous. After its appearance in Australia, the next record of it is in Spain (1869), then France (1872), England and Germany (1873), Italy (1874), Switzerland and Cape of Good Hope (1875), Austria and Hungary (1876), Greece (1877), North America (1886), Sweden (1887), and even reaching Finland (1890).

The hollyhocks on which this rust occurs are ornamental plants, and the disease may have been spread in the ordinary course of trade or exchange. The first record of a rust is by no means a guide to its first appearance, for it is generally only when it has become established and has proved injurious that it attracts attention. The prune rust, *Puccinia pruni*, which now occurs in all the States, was first observed in Queensland in 1886, and was recorded for Victoria in 1883. Although confined at first to certain districts, it has since then spread considerably, and as settlement increases it becomes more widespread.

The flax rust, *Melampsora lini*, was first determined on some cultivated flax from South Australia in 1889 by Galloway of the Bureau of Plant Industry, U.S.A. Bolley, in a letter dated 29th December, 1904, informs me that it is a very abundant rust upon all the wild varieties, and is always more or less destructive in the flax crop. It is common enough here on the native flax, and was probably introduced with flax seed.

There are four species of *Phragmidium* in Australia a genus confined to the Rose family, and only one of them is supposed to have been introduced. *Phr. subcorticium* only occurs on the imported genus *Rosa*, and was probably introduced in rose cuttings, since the mycelium of the aecidium is known to winter in the stem.

Phr. potentillae on species of *Acaena* was determined by Winter, and although referred by him to this widely distributed species, it is probably new. *Phr. longissimum* was first discovered at the Cape of Good Hope, and is now known to occur in other parts of Africa. Its appearance on a native *Rubus* in Queensland would seem to support the generally accepted opinion of a former land-connexion between Africa and Australia. But Wallace in his *Island Life* offers an alternative view. "We should prefer to consider the few genera [of plants] common to Australia and South Africa as remnants of an ancient vegetation, once spread over the Northern Hemisphere, driven southward by the pressure of more specialised types and now finding refuge in these two widely separated southern lands." From the shape and arrangement of the teleutospores and their germination immediately on ripening, this species stands apart from the others belonging to this genus, and Dietel¹³ draws the conclusion that it separated at a very early period from the common stem of the genus *Phragmidium*, a conclusion which harmonizes with the views of Wallace.

But the most interesting case of distribution is that of *Phr. barnardi*, which is not confined to Australia as was formerly believed. Quite the same type has now been found in Japan on the same host-plant (*Rubus parvifolius*), and, according to Dietel¹³, it is simply a variety of the Australian species, having fewer cells in the teleutospore, and therefore distinguished as variety *pauciloculare*.

A number of plants are common to Eastern Asia and Australia, and *R. parvifolius* is included by the late Baron von Mueller in a list of plants which extend from Eastern Australia to Japan. There are various ways in which the species may have attained to its present wide distribution, which is given as Malaya, China, Japan, and Australia. Birds may have carried the seeds, and with it some attached spores of the fungus to the Asiatic continent, or inversely from Japan to Australia. There is also the possibility of a former land-connexion between Australia and Asia, which is assumed by the zoologists, and at that time the two forms of *Phr. barnardi* may have existed. The flora of Japan, like that of Australia, is regarded as being of the same character as that of the Tertiary period, so that the wild raspberry and allied plants had plenty of time to spread from a point to the north of both Australia and Japan, carrying with them to their new homes, the rusts already developed upon them.

CHAPTER XIV.

INDIGENOUS SPECIES WITH THEIR HOSTS.

The great majority of Australian rusts complete their life-history on one and the same plant, and are thus autoecious; but, although heteroecism, or the division of the life cycle into two generations, each on different host-plants, has not yet been proved for any of them, still it has been so well established for several in other countries, that we may accept it for the present as likely to hold good here. As to the recognised indigenous species which are also heteroecious, there are only four—*Puccinia agropyri*, *P. agrostidis*, *P. magnusiana*, and *P. caricis*—the three former on Gramineae having their aecidial stage on Ranunculaceae, and the latter on Cyperaceae with its aecidial stage on Urticaceae.

If we arrange the indigenous species of rusts known in Australia under the different families of their host-plants, which are further classified according to their predominance, as determined by the late Baron von Mueller (Table) some interesting deductions may be made; but it must always be remembered that the number of known species is probably far short of those actually existing. Under these circumstances our conclusions can only be partial, still, even with these limitations, it will be instructive to compare the predominance of the native host-plants with that of the native rusts. It is found that the greatest number of rust-species occurs on the families of native plants which are large in point of numbers. Thus the Leguminosae with the greatest number of species have eighteen different rusts, while the Compositae, which only stand fourth in the list, have seventeen. At the same time it ought to be noted that future discoveries may alter this relation. For no less than seven species of the new genus, *Uromycladium*, have been added to the Leguminosae within the last few years.

The Cyperaceae, which succeed the Compositae, have only four species, while the Gramineae, which come next, have thirteen species. Then the Liliaceae have seven species and the Rubiaceae five; but on the remaining families they vary from one to five. The Leguminosae and Compositae have eighteen and seventeen species respectively, the Gramineae coming third with thirteen species. The grasses and composites are generally herbaceous, quick-growing plants, with succulent leaves, and the rust-fungi can most readily penetrate their tissues and secure during the growing season sufficiency of food. They would also be guided in their choice by the chemotactic nature of the substances contained in the host-plants; but there are so many factors which enter into the choice of a host-plant by a rust that we can only mainly at present note their preferences. Confining our attention now to the species of *Puccinia* alone and comparing them with the numbers and distribution as given in Sydow's *Mono-graph*, it is found that while one-fourth of all the species inhabit Compositae and one-eighth occur in Gramineae, so with the native *Puccinias* in Australia more than one-seventh belong to the Compositae and one-ninth to the Gramineae. In the Leguminosae only one species has been met with, and only fifteen species are recorded altogether.

TABLE OF INDIGENOUS SPECIES ON NATIVE HOSTS.

	PUCCINIA.	URONYCES.	URONYCLADIUM.	CRONARTIUM.	MELAMPUSORA.	CAEOMA.	AECIDIUM.	CREDO.
Leguminosae—	<i>P. zorniae</i>	<i>U. bicinctus</i> <i>U. fusisporus</i> <i>U. hardenbergiae</i> <i>U. phyllodiorum</i>	<i>Ur. alpinum</i> <i>Ur. bisporum</i> <i>Ur. maritimum</i> <i>Ur. notabile</i> <i>Ur. robinsonii</i> <i>Ur. simplex</i> <i>Ur. tepperianum</i>	<i>C. jacksoniae</i>			<i>A. eburneum</i> <i>A. platylobil</i> <i>A. soleniforme</i>	<i>U. bossiatae</i> <i>U. pallidula</i>
Proteaceae—								
Compositae—	<i>P. angustifoliae</i> <i>P. brachycomae</i> <i>P. calocephali</i> <i>P. calotidis</i> <i>P. erectititis</i> <i>P. gnaphalii</i> <i>P. kalchbrenneri</i> <i>P. lagenophorae</i> <i>P. oleariae</i> <i>P. podolepidis</i> <i>P. tasmanica</i> <i>P. vittadiniae</i>						<i>A. cybonoti</i> <i>A. monocystis</i> <i>A. oleariae</i>	<i>U. angiosperma</i> <i>U. bidentis</i> <i>U. crepidis-japonicae</i>
Cyperaceae—	<i>P. carici</i> <i>P. cyperi</i> <i>P. longispora</i>							<i>U. scirpi-nodosi</i>
Gramineae—	<i>P. agropyri</i> <i>P. agrostidis</i> <i>P. bromina</i> <i>P. cacao</i> <i>P. cynodontis</i> <i>P. flavescens</i> <i>P. magnusiana</i> <i>P. perplexans</i> <i>P. subnitens</i> <i>P. tepperi</i>	<i>U. danthoniae</i> <i>U. ehrhartiae</i> <i>U. tenuiculis</i>						
Orchideae—		<i>U. microtidis</i> <i>U. orchidearum</i> <i>U. thelymitrae</i> <i>U. puceinioides</i>						
Goodeniaceae—	<i>P. brunoniae</i> <i>P. dampterae</i> <i>P. gilgiana</i> <i>P. saccardoi</i>							

Rutaceae—	P. boroniae P. correae P. eriospermis	U. bulbini U. tricornes							U. anguillariae U. getonoplesi U. schelham- merae
Liliaceae—	P. burchardiae P. wurmbeae								
Rubiaceae—	P. coprosmae P. oliganthae P. operculariae	U. asperulae						A. plectroniae	
Chenopodiaceae—	P. dielsiana P. kochiae	U. atriplicis							U. rhagodiae
Malvaceae—	P. heterospora P. plagianthi								
Umbelliferae—	P. xanthosiae								
Amarantaceae—		U. polycnemi							
Sapindaceae—		U. diploglottidis							
Stylidiaceae—	P. stylidii								
Dilleniaceae—	P. hiebertiae								
Rhamnaceae—									U. spyriddii
Scrophulariaceae—		U. limosellae						A. disciforme A. veronicae	
Convolvulaceae—	P. dichondrae								
Haemodorraceae—	P. haemodori								
Cruciferae—	P. cruciferae								
Apocynaceae—	P. alyxiae P. carissae							C. apocyni	
Campanulaceae—	P. aucta								
Acanthaceae—	P. mussoni								
Ficoideae—	P. tetragoniae								
Loranthaceae—	P. loranthicola								

TABLE OF INDIGENOUS SPECIES ON NATIVE HOSTS—continued.

	PUCCINIA.	UROMYCES.	UROMYCLADIUM.	PHRAGMIDIUM.	CRONARTIUM.	MELAMPYSOKA.	CAEOMA.	ACIDIUM.	UREDIO.
Caryophyllaceae—		U. scleranthi							
Polygonaceae—	P. ludwigii P. muchlenbeckiae	U. politus							
Gentianaceae—									
Zygophyllaceae—		U. vesiculosus						A. nymphoidis	
Anaryllidaceae—	P. hypoxidis								
Ranunculaceae—							C. clematidis	A. calthae A. ranunculacearum	
Tremandraceae—	P. pfitzelliana								
Rosaceae—	P. gel			P. barnardi P. longissimum P. potentillae					
Juncaceae—	P. juncophila P. tenuispora								
Violaceae—	P. hederaceae								
Geraniaceae—	P. gerani-pilosi P. morrisoni								
Crassulaceae—									
Onagraceae—	P. epilobii-tetragoni								U. fillicae
Plantaginaceae—								A. plantaginivariae	
Hypericaceae—						M. hypericorum		A. disseminatum	

It is worthy of remark that on some of our most predominant families, such as Myrtaceae and Proteaceae, which are only exceeded by the Leguminosae, the rusts are practically absent. It is passing strange that upon our numerous Eucalypts and kindred species not a single rust-fungus should have developed, while in the Proteaceae, with their wonderful variety of foliage, only a single species, and that a *Uredo*, is recorded. *Melampsora eucalypti* Rabh. found in Calcutta on the leaves of *Eucalyptus globulus* is merely a name, and the specimens show no indications of a rust. I have carefully examined the original specimen in Rabenhorst's *Fungi europaei* 2592, and while the leaves have numerous blister-like swellings over them, they are found to consist of discoloured cells, the epidermal cells particularly being brown and discoloured, and might superficially be mistaken for spores.

In the preceding table only indigenous rusts are given which occur on native host-plants, but such rusts may either be confined exclusively to native plants or they may occur on other allied introduced plants growing here as well. Thus *Puccinia tasmanica* is found on the introduced weed the common groundsel (*Senecio vulgaris*), but one stage of it is also found on native species of the same genus, and, therefore, it is regarded as indigenous. The rust may also be found on native plants, though in other parts of the world on allied species, and yet be regarded as native, as in the case of *P. perplexans* and *P. agropyri*. There are even cases where native rusts, or at least rusts not known elsewhere, are confined exclusively to imported plants, as *P. calendulae*, *P. cinerariae*, and *P. distincta*. As regards introduced rusts, they may be found on both native and imported plants, the presumption being that the rust spread from one to the other, though some may incline to the view that these are as much natives of Australia as of any other country. Disregarding *Puccinia graminis*, there are four such species, *P. menthae*, *P. malvacearum*, *P. thuemeni*, and *Melampsora lini*. There is still another group consisting of introduced rusts found here on imported plants alone, such as *Puccinia chrysanthemi* and *Phragmidium subcorticium*.

CHAPTER XV.

AUSTRALIAN DISTRIBUTION.

It would be premature to attempt to arrange the Australian rusts in geographical districts, since they are as yet too imperfectly known, and large areas have not been explored sufficiently to give any exact idea as to the number of species or the distribution of those already known. So for the present I will content myself with indicating their distribution in the different States, and this may lead to a filling up of many of the gaps, when it is seen what species may exist in one State, and are probably to be found in some of the others.

There is one evident way in which our knowledge of this group might be extended and the area of distribution made better known. They depend for their existence on the occurrence of suitable host-plants, and since these are given for each species, as far as known, wherever the host-plants are to be found, there the parasites might be looked for.

The total number of species at present recorded is 161, and they are distributed among the different genera as follows:—

	1905.		1892.
Uromyces	27	...	13
Uromycladium	7	...	—
Puccinia	90	...	24
Phragmidium	4	...	4
Cronartium	1	...	1
Melampsora	2	...	3
Roestelia	—	...	1
Caeoma	2	...	0
Aecidium	15	...	16
Uredo	13	...	10
	<hr/> 161		<hr/> 72

It will be seen that the Puccinias constitute more than one-half of the whole, and the Uromyces come next.

In Cooke's *Handbook of Australian Fungi*, published in 1892, there are only 72 recorded, or less than half the number, and even some of these do not stand the test of further investigation. In *Melampsora*, for instance, there are three species given, and two of these must be withdrawn, one belonging to another species also recorded, and another not being a rust at all. And in Sydow's *Monograph*, just completed for the Puccinias, only 43 are given for Australia.

The following list shows the distribution of species in the different States, and it is naturally very unequal. In Victoria, which heads the list, there has been a zealous band of collectors stimulated into activity by the late Baron von Mueller and encouraged by a progressive and active Field Naturalists' Club. In Queensland the Government Botanist has always been most enthusiastic in working up the Fungi generally, and in New South Wales and Tasmania good progress is being made. Although South Australia does not possess an official Government Botanist, that State is fortunate in having such a zealous Botanist as J. G. O. Tepper, F.L.S.,

who has given special attention to this group, and has not only described some species himself, but has had several named in his honour, such as *Puccinia tepperi* and *Uromycladium tepperianum*.

—	No. of Species.	Victoria.	New South Wales.	Queensland.	South Australia.	West Australia.	Tasmania.
Uromyces ...	27	21	12	7	6	...	6
Uromycladium	7	7	3	1	2	1	6
Puccinia ...	90	69	26	14	15	10	28
Phragmidium ..	4	3	...	1	3	...	2
Cronartium ...	1	1	...	1	...	...	1
Melampsora ...	2	2	1	...	1	...	1
Caeoma ...	2	1	...	2	...	...	...
Aecidium ...	15	9	5	3	...	1	7
Uredo ...	13	5	3	4	...	1	2
Totals ...	161	118	50	33	27	13	53

CHAPTER XVI.

THE ORIGIN AND SPECIALISATION OF PARASITISM.

In a group of parasitic fungi like the rusts the question naturally arises, How did this parasitic habit originate? Parasitism in fungi is an adaptation whereby the fungus can directly draw its nourishment from the living material, and in order to do this it must have become accustomed to a new mode of life, for it is assumed that originally the fungi obtained the requisite substances for food from dead or decaying organic material.

The saprophytic mode of life seems to have led up to the parasitic, for there is every sort of gradation between the two. Some parasites are able to complete their development entirely on artificial nutritive media. Others require to infect the living plant first, and then undergo their final development on dead tissue, while others begin their life on dead material, as a preparatory stage to passing over to the living substance.

The origin of parasitism and that of specialisation are so intimately bound up that they may be conveniently considered together, for at the critical moment, when the spore first put forth its germ-tube into the living tissue of a particular host-plant and was able to grow there, then parasitism was established, and if the fungus confined itself to that host then specialisation had begun.

What induced the fungus to enter the living plant by means of its germ-tube, and afterwards confine itself to one or a few closely-allied species is the question to be answered. It does not seem difficult to account for the entrance of the germ-tube into the stoma, for it follows the lines of junction of the cells, and ultimately comes to a stoma, into which it dips just as it would into any other opening. But to be able to penetrate the cells and abstract nourishment from them is the point which requires explanation.

It is assumed that the saprophytic habit was the normal one among fungi, and that parasitism is an acquired habit. Massee⁹ claims to have proved this assumption to be a fact, for he says—"A saprophytic fungus can be gradually educated to become an active parasite to a given host-plant, by means of introducing a substance positively chemotactic to the fungus into the tissues of the host. By similar means a parasitic fungus can be induced to become parasitic on a new host." Parasitism, then, is due to chemotaxis, which is a form of sensitiveness in the plant whereby it has an affinity for certain substances, and is opposed to others. Thus there are various substances which are capable of attracting or repelling the germ-tubes of fungi, and the name of positive or negative chemotaxis has been given to this property.

In an extensive series of experiments conducted with both parasitic and saprophytic fungi, Massee⁹ has shown that certain substances in the plant are positively chemotactic in their nature, and others negatively so. Thus it was found that sugar is the most general of positive chemotactic substances, although its action on the germ-tubes of obligate parasites is very slight. Experiments showed that "it was not sufficiently powerful in any instance to attract the germ-tubes through perforations in mica or through stomata."

Specialisation of Parasitism.

Recent investigations in connexion with heteroecious rust-fungi, or those which change their hosts and produce a different kind of fungus on each

host, together with the results of infection experiments, have considerably modified our views as to the limits of species in such fungi.

Eriksson¹, in dealing with cereal rusts particularly, found that they were not liable to infect indiscriminately the different cereals, but were confined to one, or, at most, a few closely-allied host-plants, and to this phenomenon, so widespread among parasitic fungi, he applied the appropriate name of specialisation.

As examples of specialisation among heteroecious rust-fungi may be given those of *Puccinia coronata*, Corda, and *P. graminis*, Pers. Klebahn¹ proved by infection experiments that the crown rust on *Dactylis glomerata* and other grasses only produced its aecidium on *Frangula alnus*, while that on *Lolium perenne* required for its aecidial host *Rhamnus cathartica*. Hence the old species was split up into two, which can also be separated by morphological characters. Eriksson¹ also proved in 1894 that the well-known and much-investigated species of *Puccinia graminis* could be split up into a series of forms, all of which agreed in producing aecidia on the barberry, but differed in the uredo and teleutospore generations, only being able to infect special host-plants. *Puccinia dispersa*, Eriks., was proved to be an independent species, with uredo and teleutospores on rye, and its aecidia on species of *Anchusa*. Included in this were a number of forms which had no known aecidial stage, and they were afterwards separated and raised to specific rank as *P. triticina*, *P. bromina*, *P. agropyrina*, &c.

If a general view be taken of this phenomenon it is found that when two closely-related species, say, A and B, are attacked by a rust-fungus, the one on A will not infect B, and that on B will not infect A, even although the two fungi are the same species, regarded from a morphological point of view. There must, however, be some adaptation between the host and the fungus, so that the latter is attracted towards the one host and repelled by the other. But it has been shown by Ward¹ that occasionally a spore from A may gain a footing on B, and once having done this it can continue to infect B, since it has now become adapted to it.

According to the same observer, parasites may be educated to attack fresh plants by means of what he calls bridging-species. Thus, while the parasite on A may be unable to infect B, it may be able easily to infect a related species C, and after establishing itself on C it may then have the power to infect B, so that C becomes the bridging species from A to B.

Massee⁹ has also shown that a parasitic fungus can be led to attack a new host-plant by injecting a substance positively chemotactic to the fungus into the tissues of the living leaf.

Parasitism is thus an acquired habit, and, generally speaking, it becomes specialised, because only in certain plants are the substances present which attract the fungi, while in others there are also certain substances which repel, and thus prevent their germ-tubes gaining a footing in the tissues.

But in contrast to this specialisation, there occurs in a few species what may be called general parasitism, where the parasitic fungus is able to infect host-plants widely separated in their affinities. Fischer³ and Klebahn¹ have shown that *Cronartium asclepiadeum* can attack plants belonging to such distantly related families as Ranunculaceae and Scrophulariaceae, as well as Asclepiadeae, so that it has become necessary to unite under this name, species which were formerly separated on account of the difference of host-plant.

Chemotaxis can hardly be held accountable for such a widely-divergent distribution of host-plants, and although it does not clear the matter up, it may be referred to the "internal developmental tendencies" of Klebahn¹ until a better explanation is forthcoming.

The specialisation of parasitism resulting in the evolution of biologic forms is not confined to the Uredineae, but probably extends to parasitic fungi generally, which frequent more than one host, and this has been experimentally proved, particularly in the mildews or Erysiphaceae. Several biologic forms may occur within a morphological species, so that it will be necessary in the future, for the proper understanding of any such species, not only to determine its limits by means of structural characters, but also the special forms included in it with restricted powers of infection. Hitherto it has been generally assumed that the same parasitic fungus occurring on two closely related host-plants would be mutually infective, but this does not necessarily follow, even with different species of the same genus.

Neger¹, in 1902, proved by numerous experiments that there were biologic forms of *Oidium* for several species of *Erysiphe*, and Marchal¹ in the same year divided the one species of *E. graminis* into seven distinct forms, using only the conidia for purposes of infection. He showed that the biological form on barley was unable to infect wheat, oats, and rye, and Salmon² carried the experiments a stage further by using the ascospores, which had the same restricted powers of infection.

This difference in infective power is not due to any apparent structural change in the fungus, for the form of *E. graminis* on the wheat is indistinguishable, even under the microscope, from that on the barley, and yet the form on barley cannot infect the wheat, nor can that on wheat infect the barley.

The difference, therefore, lies in the physiological peculiarities of the host-plant, and it has been suggested that the cells of the leaf contain an enzyme which is fatal to the growth of the haustorium of any other form. But probably the action is reciprocal, and the germ-tube of the fungus finds something in the particular host-plant which attracts it, and is conducive to its growth.

CHAPTER XVII.

HETEROECISM AND ITS ORIGIN.

In a great many species the various stages of the self-same fungus, as already indicated, occur on the same host-plant, but the variety in the mode of reproduction has also brought about a variation in the mode of nutrition, for there are a number of species in which one part of their life is passed upon one species of plant, and the remainder on a totally different species. The host-plants are not even related to each other, but stand far apart in their natural affinities. Those which passed their entire existence on one plant have been called *autoecious* species, while those which spread it over different plants are called *heteroecious* species.

As a general rule it is assumed that the different forms of rust occurring on the same host-plant are genetically connected, although it is always desirable, where possible, to have experimental proof of it. In *Uromyces polygoni*, for instance, the three stages of aecidio, uredo, and teleutospores may all occur together on the same leaf, or the aecidia may occur on one portion of the plant, and the uredo and teleuto sori on another; and in both cases the species is regarded as having three stages, which are different forms of the same fungus. It is but a step further to have, say, the aecidia on one host-plant and the uredo and teleuto stages on another, and this affords a greater variety of food supply. Just as in the separation of the sexes in flowering plants, we are justified in assuming that all the different stages occurred at first on the same host-plant, but gradually, in the struggle for existence, one reproductive body matured on one plant and the others on a different plant, so that a change of food was secured and a succession of crops insured.

This heteroecism of the rusts was first discovered by De Bary in 1864, when he proved that the rust in wheat, *Puccinia graminis*, produced its uredo and teleutospores on the Gramineae, while its aecidial stage developed on the barberry.

It has thus been assumed that heteroecious species originated from autoecious species in the simple and seemingly natural way that the two generations separated, just to occupy fresh ground, at first passing over to nearly allied plants, and gradually to plants further and further removed in the natural system, until the present position of affairs was brought about that the two generations of the same fungus attack plants widely removed from each other, as far as their natural affinities are concerned.

But there is no evidence to prove that such a gradual separation took place, for even although the species of *Puccinia* on *Phalaris* may have their related aecidia on other Monocotyledons, and the *Uromyces* on the pea, with its aecidia on a *Euphorbia*, yet they are always considerably remote from each other. In fact, the view that heteroecism originated suddenly and without the different generations slowly and gradually passing from plant to plant, seems to have most in its favour. It is admittedly a difficult problem, since from the very nature of the case no one has been able to observe an autoecious fungus becoming heteroecious.

Heteroecism is only possible when more than one spore-form occurs in the life-cycle, and how the variety of spore-forms originated is capable of different interpretation. It may either have been a progressive development from the simplest forms, or it may have been a retrogression from the most highly developed forms. We may conceive heteroecism to have

proceeded from the formation of teleutospores being succeeded by aecidiospores, presumably at first both arising from the same mycelium. Next a division of labour took place, and the mycelium of the aecidia was produced by the sporidiola, while the mycelium of the teleutospore proceeded from the aecidiospore. The advance to heteroecism took place when the aecidiospores produced their mycelium in one host-plant and the teleutospores, through the sporidiola, in another, and the kernel of the matter lies in the answer to the question, How did this come about? It may either have taken place by a long series of slow and gradual changes, whereby the different spore-forms gradually accustomed themselves to the new mode of life, or it may have developed suddenly by one of the spore-forms germinating and growing on a different host-plant, and continuing to do so. But this latter view is hardly borne out by some experiments conducted by Miss Gibson¹, in which the aecidia from different host-plants were used to infect *Ranunculus ficaria*, and while the germ-tube as a rule entered the stoma freely, it was generally dead and shrivelled by the third day. This result was not supposed to be due to starvation, for she says:—"Whether the incapacity to penetrate the cells is due to lack of attractive substance or to the presence of anything actively repellent is not clear, though, as before stated, certain facts seem to suggest the presence of something harmful to the hyphae."

A few concrete examples may be given to show how far these views are borne out by facts.

De Bary considered the probable origin of three species of *Chrysomyxa* occurring in the Alps, and the relation existing between them:—*C. rhododendri* (DC.) De Bary, forms its uredo and teleutospores on species of *Rhododendron*, while its aecidiospores occur on *Picea excelsa*, the name given to this form before its connexion was discovered being *Aecidium abietinum*, Alb. and Schw. *C. ledi* (Alb. and Schw.) De Bary, forms uredo and teleutospores on *Ledum palustre*, and its aecidia also on *Picea excelsa*, there being little or no distinction between them and those of *C. rhododendri*. The third, *C. abietis* (Wallr.) Ung., forms the same kind of teleutospore on *Picea excelsa*, but the sporidiola from the germ-tube produce mycelia which only form teleutospores and no aecidia or uredospores have been observed. In seeking to account for this, he assumes a common origin of the three forms, and considers that either the original form from which they were all derived had no aecidial fructification to start with, or there was an aecidial fructification, and *C. abietis* has in course of time dropped it. The latter view is the one he favours. We can imagine these three forms competing for *Picea* as an aecidial host, and while two succeeded in establishing themselves, the third, *C. abietis*, was compelled to drop it altogether.

Barclay², in tracing the developmental history of Uredineae, attempted to show that in the struggle for existence, heteroecism was beneficial, and that if two species compete against one another for a host, that which makes for heteroecism will more probably succeed than that which makes for autoecism.

There is another interesting series of forms worthy of consideration known as "coronate" rusts, because the apex of the teleutospore is prolonged into and crowned by a number of finger-like processes. There are both heteroecious and autoecious species as follows:—

1. *P. coronata*, Corda, I. *Frangula alnus*, II., III., Grasses.
2. *P. lolii*, Niels., I. *Rhamnus cathartica*, &c., II., III., Grasses.
3. *P. himalayensis* (Barcl.), Diet. I. *R. dahurica*, II., III., Grasses.

4. *P. festucae*, Plow., I. *Lonicera periclymenium*, &c., II., III., Grasses.
5. *P. mesneriana*, Thuem. III., *Rhamnus alaternus*.
6. *P. digitata*, Ell. and Hark. III., *R. croceus*.
7. *P. schweinfurthii* (*P. Henn.*) Magn. III., *R. staddo*.
8. *P. longirostris*, Komarov III., *Lonicera hispida*.
9. *Uromyces phyllodiorum* (*B. and Br.*) McAlp. O., II., III., *Acacia notabilis*, &c.

Fischer considered that the original forms of the heteroecious species lived both on the grasses and *Rhamnus* as autoecious fungi, and that they could undergo their complete development on either of them. These original forms were thus supposed to be able to live on a variety of hosts, and it is assumed that only in recent times had they become specialised. In support of this view there is a rust—*Puccinia graminella* which produces both aecidia and teleutospores on a grass, and I have also found an aecidium on *Danthonia*, and although teleutospores were not observed on the same plant, I still regard the two as belonging to the same species, viz., *Uromyces danthoniae*.

Fischer presupposes that the original form was both autoecious and plurivorous, and it is reasonable to suppose that a fungus which could live upon two such distinct hosts as *Rhamnus* and grasses would, at the same time, select numerous other plants as hosts, so that this view hardly explains the fact. It is much simpler to suppose that since these primary forms had begun to form aecidia and eventually uredospores, they no longer carried out their complete development on their original hosts, since a change of host was in a sense equivalent to a cross in flowering plants. They accordingly changed their teleutospores (and uredospores) to new hosts, so that the autoecious stage was dispensed with because it was not so advantageous as the other.

This change of host is not a haphazard affair, but takes place according to a definite plan. It may be confined to a single or a few distinct species, and attempts to bring it about on plants which do not belong to the regular cycle, as a rule, end in failure.

But, of course, the regular host plants may fail, owing to drought or some other climatic conditions, and then the fungus often obeys the law of self-preservation, by repeating the same generation again and again. This may even become a fixed habit until the single generation is more or less independent, and then it is all that remains of what was once a complete cycle.

Among the heteroecious fungi there is a regular course of development which is usually followed. The one host-plant bears the aecidium generation, and the other host-plant the uredo and teleuto spore generations, but there are slight differences in detail which may be noted here.

The complete cycle of development, as already stated in the introduction, is the most common, in which the teleutospores germinate in the spring after a winter's rest, and produce sporidiola. The sporidiola infect the young leaves of the proper host, and produce aecidia, usually accompanied or preceded by spermogonia. Then the aecidiospores infect the host which bears the uredo and teleuto spores, but as a rule the regular course of development is interrupted by the repeated production of uredospores before the final stage is reached. The fungus is thus widely spread from plant to plant by means of the uredospores and then the teleutospores are formed in the autumn, either from the same mycelium or from a teleuto-spore-bearing mycelium proceeding from the uredospores.

This course of development may be represented graphically as follows, taking *P. graminis* as the type:—

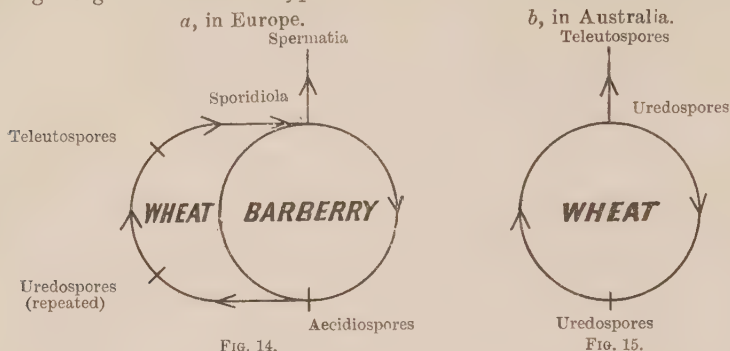


FIG. 14.

FIG. 15.

The aecidial stage of the spring rusts of wheat (*P. trititica*) or barley (*P. simplex*) is not known, but Klebahn hazards the suggestion that the hosts to which they respectively belong may only exist in their original home, and thus not hitherto observed. With such widely and extensively cultivated plants, the uredospores could easily be carried on the grain or by the wind, and the fungus could thus be perpetuated without the intervention of an intermediate host.

The tiding over of the winter is most important for those fungi which depend upon two host plants for their continued existence, but while this is usually accomplished by means of the teleutospores, other and additional measures may be taken to secure the same result. Sometimes the uredomycelium persists during the winter, and in the case of *Puccinia arrhenatheri* the aecidium-mycelium becomes perennial, and reproduces the aecidia year after year, while the teleutospore is also produced. When the aecidial stage is dropped, as in the case of *Puccinia graminis* in Australia, then there is a profuse development of uredospores in comparison with teleutospores, and there is abundance for present needs, as well as for future germination in the spring. In other cases where the aecidial host is absent, the same thing has been observed, as in *Coleosporium senecionis*, when occurring in a district destitute of fir trees, or *Chrysomyxa rhododendri* when the silver fir is absent.

Heteroecism is said to increase the vigour of the fungus, and a striking illustration is given by *Puccinia graminis* on wheat. It is sometimes said that the aecidiospores from barberry are much more virulent than the uredospores derived from the wheat itself, since the teleutospores produced are earlier, more copious, and more injurious to the wheat. With reference to this, Plowright says:—"There is a wonderful difference in the amount of injury done by mildew, when derived directly from the barberry, and when derived from uredo that has reproduced itself through several generations. . . . The fungus grows with such energy that it so injures the wheat plant as to prevent it producing more than a few starved kernels." As against this view, it may be well to bear in mind that in no country in the world probably does *P. graminis* cause as great injury to wheat as it does in Australia, a country with barberries practically non-existent, and in which the aecidial stage has never been found.

Of course further observations on a number of species are necessary to establish the fact, but Klebahn considers that the utilization of the vegetative periods and other peculiarities of the host-plants, rendered possible by the change of hosts, gives the fungus a decided advantage.

Whatever view we take as to the cause of heteroecism, it is a well-established fact that the promycelial spores, no matter how freely applied, produce no effect on the grasses which bear them, and the most probable theory as to its origin assumes that the uredo and teleuto spore generation were at first associated with the aecidia, but ultimately passed over to other hosts.

CHAPTER XVIII.

PREDISPOSITION.

Wherever epidemic diseases caused by parasitic fungi occur, the question is raised as to the relative susceptibility of different varieties or individuals. The fungus has the power of causing disease in the host plant attacked, but the latter in its turn may either be favorably or unfavorably disposed towards its development. This predisposition of the host for the attacks of the parasite is very variable, and is influenced by various factors. It is generally considered that a sickly plant is more liable to rust than a sound one; but, on the contrary, strong and sound individuals are more easily and more virulently attacked, so that for artificial infection strong-growing plants are selected. Ward⁷ has shown that when the host-plant is starved by withholding certain mineral salts, and thus stunted in growth and generally enfeebled, it is not affected in its susceptibility or otherwise. A starved plant certainly develops smaller pustules and fewer spores on account of the diminished supplies of food available for the mycelium, but the power of infection is just as great as in normal plants. As far as brome rust is concerned—and we have no reason to doubt that it holds good for others as well—predisposition and immunity on the part of the host, and impotence and virulence on the part of the parasite are alike independent of mere nutrition. But, as we shall see afterwards, certain substances not of the nature of food-material, introduced into the plant may affect its liability to disease. There are various factors, however, which may either dispose the plant towards disease or tend to render it immune, and some of these may be given here.

The age of the part attacked has an important influence on infection, particularly where the sporidiola are concerned. Young leaves and shoots are most easily infected, and when they get older little or no effect is produced. This is owing to the germ-tube of the sporidolum penetrating the epidermis direct, and it is well known that this layer becomes firmer and tougher and less easily penetrable as it gets older. The uredospores and aecidiospores, on the other hand, infect the older leaves as well as the younger, and this is easily explained from the fact that their germ-tubes enter through the stomata.

Different parts of the same plant are also variously affected. Sometimes it is the leaves, sometimes leaf and stem, and it may be on one or both sides of the leaf. The different species of rust on the same host-plant are apt to choose different portions. Thus *Puccinia triticina*, from its earlier attack, is found most commonly on the lower leaves, and extends on to the sheath, mostly near its junction with the leaf, while *P. graminis* is worse on the upper leaves, and often particularly bad on sheath and stem.

Different varieties or sorts of the same species vary considerably in their susceptibility, and, as will be shown later, it is by the selection and breeding of such rust-resistant sorts that solution of the rust-in-wheat question in Australia is being attempted. The same is the case with other rusts, and I have seen one kind of flax (*Linum usitatissimum*) badly attacked by *Melampsora lini*, and another kind growing alongside quite free. Hennings⁵ has recently made observations which tend to show that plants previously susceptible to the attacks of a parasitic fungus may gradually become immune when they are changed to rich ground where they are better nourished and more vigorous.

In 1894 several rhizomes of *Peltandra virginica* were sent to him from North America, and planted in pots. An aecidium developed on the stems and midribs of the leaves, which was found to be new and named *Aecidium importatum*. One plant was left in the pot, which was placed in water, and the others were planted out in a soil composed of damp humus. The pot plant has annually produced the aecidia up till the time of writing (1902), while the other plants only showed the fungus very slightly in 1895 and 1896, after which they grew exceedingly strong, and since then have remained perfectly sound. It must be remembered that this is a hardy marsh-loving plant, and there is probably more than mere nutrition concerned in its freedom from disease, since it would be more reasonable to regard the result mentioned as due to the change of situation than to change of soil. Salmon³ considers that the evidence which is gradually accumulating on the subject of the relations between host-plants and parasitic fungi leads us to the conclusion that immunity and susceptibility are due to constitutional (physiological) peculiarities, and not to any structural ones. He has also shown experimentally that while the uninjured leaf may be immune, the same leaf when cut or injured may become liable to infection, and the conidia produced on such leaves are then able to infect uninjured leaves. In this way the range of infection of a biologic form may be increased. Different species of the same genus, when they are generally attacked by a rust-fungus, may vary considerably in their susceptibility to infection.

If we attempt to explain the varying susceptibility of different plants or different kinds of plants, then the difficulty is apparent, and the symbiotic relation between the parasite on the one hand, and the host-plant on the other, complicates the matter. Why is the fungus able to infect certain host-plants, and not others? Why is the host-plant capable of resisting certain fungi, and not others? How is the fungus able to accommodate itself to certain plants, and not to others? These and other questions may be asked, but cannot be fully answered at present. De Bary² says:—"The physiological reason for these predispositions cannot, in most cases, be exactly stated; but it may be said in general terms to lie in the material composition of the host, and therefore to be indirectly dependent on the nature of its food."

The question has been asked, if there is any relation between liability to infection or power of resistance and the visible structural features of the leaf, and it has been answered differently by various investigators.

Hennings² lays stress upon the physical characteristics of the parts of the plant on which the parasitic fungi occur. He considers that the parasite develops differently on a thin-skinned, delicate leaf, and a thick-skinned, firm, leathery leaf. Also that the venation and hairiness of the leaf may affect the result.

Marshall Ward¹ fully investigated the structural peculiarities of the leaves of the various species of *Bromus* used in his infection experiments with brown rust—such as thickness of cell-wall and cuticle, "bloom," size, number, and distribution of hairs, distribution of chlorophyll-tissue and vascular bundles—and he arrived at the conclusion that "the resistance to infection of the immune or partially immune species and varieties is not to be referred to observable anatomical or structural peculiarities, but to internal, that is, intra-protoplasmic properties beyond the reach of the microscope."

Salmon³ comes to the same conclusion from his infection experiments with the oidium of *Erysiphe*, but the physical characters of the wheat-plant seem to have some effect on its liability to rust, for there are certain

typical characters associated with the quality of rust-resistance, and they would appear therefore to have a share in bringing about this result. In a rust-resistant wheat, the leaves have a tough cuticle, and the straw is well-glazed often with a glaucous bloom. The flag is narrow not broad, erect not drooping, stiff and firm, not soft and flabby. Still all these characters may be present, and yet the climatic conditions may overrule them and weaken the power of rust-resistance. It will thus be seen that a variety of causes may contribute to rendering a plant immune, and that not only the chemical and other properties of protoplasm come into play, but there is also the mutual reaction of the living protoplasm of host and parasite to be considered.

As far as the rust fungus is concerned, there is no such thing as a perfectly immune wheat-plant, for, given the necessary conditions of situation, heat, moisture, and spores at the right season, and at some time or another rust will appear. We express this by saying that there are "rust-resistant" wheats, but not "rust-proof."

Animals are sometimes rendered immune, or, at least less susceptible to disease, by repeated infections, so that they become gradually accustomed to the effects of the parasite, and the important question arises, Can plants also be submitted to "protective inoculation"? Inoculation with attenuated bacteria is the simplest method with animals, and this treatment retards their vegetative development, and so lessens their injurious effects. This artificially-induced immunity only lasts a certain time, varying in different cases. Ehrlich and Huebener¹ have shown, from numerous experiments upon animals, that an immunized mother can impart immunity to her offspring, but it is not lasting.

In the case of plants, as in animals, there seem to be two opposing forces at work. On the one hand, the protoplasm of the fungus is endeavouring to overcome the resistance to its entrance offered by the host-plant, while on the other hand the host is more or less successfully resisting the inroads of the fungus. There are no known cases of a plant becoming "immune" or "partially immune" by inoculation with the parasitic fungus to protect it against further attack, but advantage has been taken of the great sensitiveness of certain spores to copper salts to protect the organism against them.—(Note 6, p. 75.)

Chemotaxis is the name given by Pfeffer¹ to a form of sensitiveness which certain organisms possess towards certain chemical substances. This power, which certain nutritive and other substances have of attracting bacteria and other organisms towards them, is known as *positive* chemotaxis, and of organic substances with a high nutritive value which are positively chemotactic, may be mentioned asparagin and peptone, while sugar, which is one of the best food stuffs and richest sources of energy, has but little attractive power. The power of other substances, on the contrary, to repel bacteria, is known as *negative* chemotaxis, and free acids and alkalis, as well as alcohol, have this effect. Glycerine, as far as known, is an inactive substance. Masee⁹ has stated that immunity is owing to the absence or small proportion of the substance chemotactic to the parasite in the plant not attacked, and if a plant can be impregnated with some substance which is negatively chemotactic, and at the same time does not affect the utility of the plant, then immunity against parasitic fungi may be obtained in this way.

Laurent¹, acting on this principle, conducted a series of experiments to test the possibility of producing potatoes which would be proof against *Phytophthora infestans*. He grew very susceptible varieties in pots, to the soil of which sulphate of copper was added, and when the tubers were harvested, some were cut in two and their cut surface placed in contact with

the mildew of potato leaves. After four days, the tubers grown in the soil containing copper did not show any infection, while those grown in untreated soil were infected in a very decided manner from being brought into contact with a mildewed leaf.

Marchal², following on the same lines, tried to secure immunity to lettuce against *Bremia lactucae*, and he found that the plants treated showed considerable resistance, and the immunity seemed to be in proportion to the strength of the solution. He also experimented with cereals for protection against rusts, but without success, and the probability is that he did not use the proper substance which repelled the germ-tubes of the rust-spores when they attempted to enter the plant.

Massee⁷ experimented with cucumber and tomato plants, watering the soil on which they were grown with a solution of sulphate of copper. The result was that "not a single one of the treated tomato plants showed a trace of disease" after being sprayed with water containing the spores of the fungus, while the untreated check plants were badly diseased.

It is important to note that tomatoes produced from plants treated with solutions of copper sulphate were found on analysis to show amounts of copper not sensibly greater than that found in the fruits obtained from untreated plants.

These experiments at least show that certain substances entering into the constitution of the host-plant render it for the time being immune to the attacks of certain fungi, even although it was naturally predisposed to that particular form of disease.

CHAPTER XIX.

THE PRESENT POSITION OF THE RUST IN WHEAT QUESTION IN AUSTRALIA.

It will tend to clearness if we confine our attention to the rust in wheat, for the general considerations which hold in this case will apply to the rusts on the other cereals chiefly cultivated, viz., oats and barley. And the rust which is most important from the farmer's point of view, because it does the most damage, will be chosen viz., *Puccinia graminis*, which is so distinct in its characters that there is no difficulty in recognising it. There are only two kinds of rust in wheat in Australia, the positively injurious *Puccinia graminis* and the comparatively harmless *P. triticea*, because it does not pinch and shrivel the grain like the other. In the early days wheat and other cereals had to be imported into Sydney, but now it is grown to such an extent in the Australian Commonwealth that in the season 1903-4 there were 5,566,340 acres under wheat, yielding a total of 74,149,634 bushels. Wheat will always form one of our staple products, and from the great extent of the industry, whatever increases the yield or tends to diminish the losses from disease, will have a corresponding far-reaching effect. Ever since attention has been given to the subject, it has been found that not a year passes without its being present on wheat to a greater or less extent, and in some years, which are commonly spoken of as rusty years, it seriously injures the grain and considerably diminishes the yield. To give some concrete idea of the extent of the loss, it may be stated that in a particularly bad season like that of 1889, the loss was estimated to be for the whole of Australia between £2,000,000 and £3,000,000. In such favorable years for the rust, there is always an evident connexion between the weather and its epidemic nature. In 1889 it was a wet spring, and about the blooming season the weather was what was known as "muggy," consisting of showers with heat between, and heavy dews, so that the wheat-plant, at the time of coming into flower, was particularly susceptible, and the rust spores found a ready entrance into the tissues of the plant, with their accumulated stores of food, and thus it spread rapidly.

Atmospheric conditions are often regarded as the prime factors in the production of rust, but they are only concerned in the matter in so far as they favour or hinder the development of the parasite which causes it, and this is strikingly shown in the existence of rust-resisting wheats. Owing to the importance of the subject, and the widespread losses, delegates from the various States were appointed to meet and confer periodically, and these various conferences extended from the first in 1890 to the last in 1896. The results of their labours may be seen in their voluminous reports, which practically cover the different phases of the question. But there were some important points with which they were not then in a position to deal, such as the effects of rust on the straw and grain, and experiments in the inoculation of the barberry. These will be considered preliminary to the main question.

EFFECTS OF RUST ON THE STRAW AND GRAIN.

The visible effects of the rust on the wheat plant is well shown in Pl. XLIV., where the straw of the rust-resistant Rerraf is bright, glossy, deep yellow, and well ripened, while that of the badly rusted Queen's Jubilee has a dirty, streaky, patchy appearance. The ears of the one are full-sized and well formed, with plump, well-filled grain, and the other has poor ears with light and shrivelled grain.

But the effect upon the composition of the plant, and particularly its feeding value, is not known to the farmer, who cuts his crop for hay when rust threatens to ruin it.

This has recently been determined by F. T. Shutt¹, chemist, Dominion Experimental Farms, Canada, who analyzed two samples of wheat grown at Manitoba in the same field and of the same age, only the one was rusted and the other rust free, so that the results are strictly comparable. The analysis is as follows:—

ANALYSIS OF RUSTED AND RUST-FREE WHEAT-STRAW AND GRAIN.

	Weight of 100 Kernels.	Moisture.	Crude Protein.	Crude Fat.	Carbo- Hydrates.	Fibre.	Ash.
	Grams.						
Straw from rust-free wheat	...	7.92	2.44	1.65	39.00	39.95	9.04
Straw from rusted wheat	...	7.92	7.69	1.97	38.44	36.78	7.20
Grain from rust-free wheat	3.0504	12.26	10.50	2.56	70.55	2.29	1.84
Grain from rusted wheat	1.4944	10.66	13.69	2.35	68.03	3.03	2.24

The Straw.—It is pointed out that in crude protein the rusted straw is much richer, and since this includes all the nitrogenous compounds of a food that go to repair waste, form blood and build up muscle, it may safely be concluded that the rusted straw is much superior in feeding value. There is also in the rusted straw slightly more fat and somewhat less fibre, so that all this affords additional evidence of its more highly nutritious nature.

The handling and feeding of rusty straw in Australia from the farmer's point of view has received attention. The experience of one who has done a deal of threshing is to the effect that when very bad it caused an itchy sensation, and made the men about the thresher rub their skin until it was broken. As regards feeding rusty hay, another with large experience informs me that horses and cattle relish it far before ordinary hay. Of course, it was fed as chaff.

The Grain.—This from the rusted wheat is only about one-half the weight of that from the rust-free wheat, but as the protein content shows, it has, weight for weight, a considerably higher nutritive value. He accounts for the higher protein content in the smaller grain in its larger proportion of bran, but chiefly in the partial and incomplete transference and accumulation of starch.

These results likewise afford interesting evidence as to the physiological effect of the rust on the wheat plant, and agree with what has been deduced from other data.

In the actively growing and feeding period of the plant's life, it is apparently able to provide for the wants of the fungus as well as its own, and therefore its vitality is not seriously affected. But when the second period of forming and ripening the seed arrives, when feeding is gradually ceasing, and the accumulated materials are being transferred to the seed, then the fungus draws upon the plant's capital, crippling its energies, and checking the movement of the food materials to the seed. As Shutt summarizes the whole process:—"The growth of the rust arrests development, and indicates premature ripeness, which, as we have seen, means a straw in which still remains the elaborated food, and a grain small, immature, rich in protein and deficient in starch."

This emphasizes what we have frequently insisted on, that the critical period, literally the turning point in the plant's life, is reached when it

begins to form the grain, and if that season is favorable for the development of rust, then the fungus has to draw upon the stored-up material, and consequently the grain is not fully formed, if at all. Incidentally this investigation also throws light upon the reason why the earlier rust (*P. triticea*) is comparatively harmless, since its period of greatest activity is when root and leaf are busy manufacturing material sufficient to provide for the necessities of both.

On account of the comparatively late appearance of *P. graminis*, it is by some considered to do the least damage to the grain, but, as a matter of observation, and on physiological grounds, it is known, at least in Australia, to be the most injurious.

Puccinia Graminis and the Barberry in Australia.

In Europe and America the identity of *P. graminis* is determined, not merely from its morphological characters, but from its ability to infect the barberry and produce aecidia. But in Australia infection of the barberry has not been successful, although several attempts have been made, and some have doubted whether we have got the true *P. graminis*, and not a distinct biological form of it. From a comparison with European specimens and a critical examination of the sori, the uredo and teleuto spores, there is no doubt that the rusts are very much alike, only if the infection of the barberry is accepted as a diagnostic character, then the identity is not proved. The relation of this rust, therefore, to the barberry in Australia became a pressing subject for experiment.

The germination of the teleutospores may be easily accomplished at the proper season, either by placing them in a drop of water on a slide under a bell-jar, or, better still, if copious germination is required, by taking some of the rusty straw and placing it on a drop or two of water in a petri dish, the cover of which is lined with damp blotting-paper. It is only after a considerable rest that they will germinate, and they start on warm days about the end of September, which is the beginning of our spring. This may continue through the warmer days of October, almost or entirely ceasing in a cold spell, and even until November germination continues if the conditions are favorable; but although numerous trials have been made, no germination has occurred outside these months. Generally speaking, the middle of October is the height of the season for germination, and then, too, the uredospores may be multiplying rapidly on the growing wheat-plant; so that there is no "off" season in Australia, as far as wheat is concerned, when the teleutospores are active and the uredospores dormant. In any case, as our wheat crops are usually harvested in November and December, even if the barberry were common, and developed rust freely, it could hardly be of much importance as a factor in spreading the wheat rust, since the aecidia would not be developed profusely before the wheat crop had passed the danger point.

The barberry is not a native of Australia, and very few hedges exist, so that the question of its infection is not of great immediate practical importance, but it is of high scientific value to establish the fact that the rust may pass one portion of its life on one plant, say, wheat, and continue it on a very different plant as an intermediate host, say, barberry, and thus settle that the rust with which we have to deal is the *P. graminis* of Europe.

As early as October, 1892, I succeeded in germinating the spores freely and copiously in a watch-glass with water, and infected four different species of barberry obtained from the Botanic Gardens, two of which were

known elsewhere to carry the aecidial stage of *P. graminis*. In one case the infected branch was placed under a bell-jar to preserve moist conditions, but there was no result with any of the species, since the weather was too hot and dry.

In 1902, in order to give the experiment another trial under the most favorable conditions, Dr. Plowright kindly forwarded several young barberry bushes from England, which arrived here in December in good condition. Rusted straw was specially kept exposed to the weather in order to inoculate the barberries. About 16th September the barberries were putting forth their young leaves, and looked very healthy. One was kept as a check, and the others were infected, either by scattering rusted straw around the plants and tying it on to them, or, in two cases, by applying germinating spores direct to the leaves. Some plants were kept under bell-jars, others exposed, and all were attended to and watered freely. The result was that not the slightest trace of any fungus appeared on any of the barberry leaves. It may be stated that the conditions for fungus growth were most favorable, as at times that muggy heat prevailed, which so quickly spreads the rust in a growing crop.

In 1904 the experiments were continued in the pots, partly on the same lines with rusted straw, and partly by planting a rusty wheat beside the barberry, so that it might be naturally infected next season.

Cuttings from the English barberries have also been planted at Port Fairy in a rusty spot where they have thriven, and Queen's Jubilee wheat planted around them produced abundance of *P. graminis*. The rusted straw was allowed to die down on the spot, and every facility given for the inoculation of the barberry, but without result so far. Some *P. graminis* on wheat was sent by Dr. Plowright in March, 1903, which was gathered in September, 1902, and kept in his garden till March. On arrival here some of it was kept inside, and a portion placed outside exposed to the weather, just as was done with Australian rusted straw. It was thus exposed during our winter months of June, July, and August, and in September it was tested, being then exactly twelve months old. While the teleutospores about six months old from the Australian wheat germinated freely, there was no change in the spores from the English wheat, and although attempts were made at different times, there was never any sign of germination. Probably they were kept too long, as they might have germinated on or about the English spring. Prior to this, I had sent rusty Australian straw for trial to Dr. Plowright, but none of the teleutospores showed the slightest trace of germination. Writing in the *Gardeners' Chronicle* for 15th January, 1898, he says⁶:—"I have tried on two occasions to get the teleutospore of *Puccinia graminis* from Australia to germinate in England, but I have not succeeded. The first attempt was made nine years ago, when Mr. D. McAlpine was good enough to send me material; but I was quite unsuccessful. Last year he was kind enough to send me a further supply; but, although I kept the straw out of doors during the latter part of last winter and the spring of 1897, I was equally unsuccessful. Is it probably like the seeds of some of the higher vegetables, the teleutospores require not only a period of rest, but also an exposure to a certain degree of cold?" Seeing that the spores germinated freely here, the "exposure to cold" theory does not hold; and the most probable explanation is that they had been kept too long, and attempts to germinate them should have been made in the English autumn. As far as Australia is concerned, the rust which does the principal damage has apparently no intermediate stage.

The Australian rust has been determined as *Puccinia graminis* by Eriksson and other authorities; but if the ability to produce the aecidium on the barberry is taken as the final criterion, then judgment must be suspended in numerous other cases. Thus Masee⁴ has found *P. graminis* on *Alopecurus pratensis*, and *Avena elatior* in the Royal Gardens. Kew; but he significantly adds—"Notwithstanding the great quantity of *Berberis* and *Mahonia* present in the grounds, the most careful and continued search has failed to reveal the presence of the aecidiospore stage." (Note 7, p. 75.)

THE PROBLEM STATED.

In dealing with the rust question from a practical point of view, there were two main issues to be determined:—

1. How is the rust spread and continued from season to season?
2. How may its injurious effects be mitigated or counteracted or prevented?

The first question is a most important one, for if we could find out where, and under what conditions, the rust is lying dormant during the time from reaping the crop to sowing it again, then we might be able to destroy it at this stage, and prevent its reappearance. Although the question may thus be simply stated, it is by no means easy to answer.

The second subject of prevention or mitigation will evidently depend on our knowledge of the life-history of the rust fungus, as well as of the wheat plant itself, and how far the conditions can be controlled which render it susceptible to the fungus.

How the Rust is Spread and Continued from Year to Year.—We know exactly now, thanks to the labours of Eriksson, Marshall Ward, and others, how the rust-spores enter the plant by means of their germ-tubes, how they grow and ramify among the tissues, and drain them of their contents, until they again form a spore-layer, and reproduce the spores on the surface in great abundance. We thus know how fresh spores originate once they have got a start; but it is the starting-point which is the difficulty.

Although the rust was known, and the effects produced by it were familiar from remote antiquity, yet its true nature was not discovered until the latter half of the eighteenth century. As late as 1733, Jethro Tull, writing about it in his *Horse-hoeing Husbandry*, attributes it to the attacks of small insects "brought, some think, by the East wind, which feed upon the wheat, leaving their excreta as black spots upon the straw, as is shown by the microscope." In 1767, its true nature as a fungus, and therefore as a plant, was determined by Felice Fontana, and in 1797, Persoon gave it the name by which it is still known, *Puccinia graminis*. The rust then is a fungus growing inside the wheat-plant, and living at its expense, and reproducing itself by means of minute seed-like bodies or spores, which are so conspicuous on the leaves and stem of the wheat at certain seasons.

For a long time there was a suspicion in the minds of many practical farmers that the barberry bush had something to do with its spread, and so firmly was this believed in, that the State of Massachusetts passed an Act compelling the inhabitants to extirpate barberry bushes. And when De Bary, in 1864, justified the farmer, and proved scientifically that there was a connexion between the fungus which appears on the barberry bush, and that which appears on the wheat, then it was thought by many that we had reached the root of the matter, and that we had simply to destroy the barberry bush in order to get rid of the rust. But it is well

known that here in Australia, where barberry bushes are not native, and where they are comparatively scarce, the rust is particularly bad in certain seasons, so that there must be other causes to account for the prevalence of rust.

The connexion between wheat-rust and barberry has already been discussed, so need not be further referred to here. There are several possible ways in which the presence of the rust year after year may be accounted for, and it may be worth while to consider some of these.

1. The uredospores produced in such immense numbers may serve to carry it on. They are very minute and light, easily distributed by the wind, and it has been shown that they exist in the air and on the ground. They might thus be readily transported and even carried to localities far removed from wheat-growing areas, in some cases by the duststorms which are very prevalent in the northern parts of Victoria. But the mere presence of spores is not sufficient to account for the rust being spread, since they must be capable of germination. I have often tried to germinate uredospores taken from straw that had been left on the ground, but without success. My latest attempt was with uredospores still retaining their colour from a sorus on a dead leaf of Queen's Jubilee wheat on March 25th. The spores were kept moist under a bell-jar, but not a single one germinated. But the result is different when spores are taken from self-sown wheat growing in the interval between the two crops.—(Note 8, p. 75.)

2. These spores are not only in the air and on the ground, but they are commonly to be found entangled in the bearded tip or "brush" of the grain. In one variety, Queen's Jubilee, this was so common that not a single grain could be found without the uredospores. Dr. Cobb¹¹ has likewise examined the brush of a number of varieties in New South Wales, and found in about 57 per cent. of the grains examined that the spores were in the brush. This is an evident starting-point for the rust, but not the only one, since seed wheat treated with bluestone, formalin, corrosive sublimate, and other fungicides, produced rusty plants, and in fact there was little difference as regards rust between the plants from treated and untreated seed.

3. It was commonly supposed until recently that the rust could readily pass from one cereal crop to another, and thus it was passed on to the wheat at the proper season. This view was put forward as late as September, 1904, in the *Journal of Agriculture* of South Australia, by A. Molineux¹, who states:—"I have observed for many years that when ever we have a mild autumn and summer, accompanied with occasional showers, we have complaints of red rust in the succeeding crop; and I have been led to the belief that until the new wheat crops have started, the rust is nursed by the wild oats and other cereals that may always be found growing on the headlands and by the roadsides." Of course, this is a very convenient way of accounting for the presence of rust throughout the year, but Eriksson has shown that the spores from oats will neither infect wheat nor barley, nor will the spores from the barley infect wheat or oats. It follows from this that adjacent fields of these crops will not affect or be affected by each other, so far as this rust is concerned. Probably, however, Molineux's view is correct, except that it is the self-sown or volunteer wheat growing in our paddocks or on the headlands that carry it over. The system of harvesting practised in Australia with the combined harvester, which takes off the heads only and delivers the winnowed grain into bags, necessarily implies the scattering of a certain amount of seed on the ground, and this germinates with the first rain, and is almost always partly rusted, and often badly so. Our hay being largely made

from wheat, when rains fall shortly after it has been cut, the second growth or aftermath is almost always rusted, and so a second crop of uredospores is produced.

4. Since "intermediate hosts," such as the barberry, are not concerned in carrying over the rust from season to season, it has been suggested that infection may be communicated to the wheat from other grasses which, as we have elsewhere shown, may also be attacked by *Puccinia graminis*. Klebahn¹ (p. 230) has shown that uredospores from various grasses will infect wheat, and it remains to be determined how far the grasses occurring in our wheat-fields, and attacked by this rust, are capable of infecting it.

5. Towards the end of the growing season, a second kind of spore is produced, known as the teleutospore. It will not germinate immediately, but only after a period of rest, and it may also aid in carrying over the rust from season to season. But although it can germinate in the spring, and produce other minute spores known as sporidiola, still they have not been proved to infect the wheat-plant, and so we do not know what purpose they serve, if any. In other countries they are said to germinate upon barberry leaves, and produce the aecidial form of the rust—and it may be that here they are simply dying out—are becoming functionless, because the barberry bush which they normally infect is not now available for them.

6. There is still another way in which some rusts are propagated, and that is by means of the threads of the fungus or mycelium remaining inside the seed and starting into life with the germination of the grain. But although hundreds of seeds have been carefully examined by the microscope, no trace of this has been found, and therefore for the present we must decline to regard it as a probable cause.

7. There still remains another possible means of continuation from season to season, which has been prominently brought forward by one who has devoted considerable attention to the study of the rusts in Sweden, Professor Eriksson. Although he has not yet succeeded in giving scientific proof of his theory, he considers that while infection by spores does occur, yet the primary infection is from within, from an internal germ of disease inherited from the parent plant and latent in the seed. He grew wheat in closed chambers, where it was believed to be secure against infection from without, and still the rust appeared all the same, and he can only account for this by supposing that in the cells of the seed the protoplasm is associated with the plasma of the fungus—what he calls *mycoplasm*—and from this there arises, if the conditions are favourable, the mycelium of the rust fungus, quite independent of external infection. He does not seem to have considered the possibility of the spores of the fungus being attached to the seed, and until the soil and the seed are thoroughly sterilized and every precaution taken to exclude infection from without, and the disease still produced, until then we must suspend our judgment and accept the Scotch verdict of Not Proven. A very striking case, however, that the seed may be the means of continuing rusts from season to season is given by Carleton³ in connexion with Euphorbia rust (*Uromyces euphorbiae*, Cooke and Peck). The pods of *Euphorbia dentata*, and even the naked seeds, were found to be affected with aecidia, and on growing the rusted seeds under a bell-jar, those that were disinfected produced plants without rust, while those not disinfected gave rise to rusted plants. Here the seeds actually bore the aecidia, and propagated the rust through the germinating seed. A similar instance is met with in *Aecidium platylobii* McAlp., where the aecidial cups are borne on the pods, and on opening the diseased ones, the seeds are frequently found covered with the mycelium, which, on microscopic examination, is found to penetrate them.

PREVENTION OR MITIGATION OF THE RUST.

The all-important question now remains to be answered, how to prevent or mitigate the effects of the rust. In the various reports of the Rust-in-Wheat Intercolonial Conferences, special attention was paid to the solution of this question, and the effect on the crop of different cultural methods received a large share of attention.

Drainage.—It is commonly affirmed that rust is worst in hollows, where water lodges, and on general grounds it is considered that drainage by removing the surplus moisture would tend to afford the wheat the most favorable conditions for its healthy development, and thereby render the rust less injurious. But, as a matter of fact, when it was experimentally tested in Victoria, an increased yield was the result; but as regards rust, it did not seem to affect it, for out of six areas artificially drained, five of them were rusty. In a number of our wheat-growing areas, it is not excess of moisture in the soil, but deficiency of it, which is complained of, and in such areas the rust is very severe in seasons marked by copious late spring rains.

Irrigation.—At the present time irrigation is the great problem which overshadows all others in connexion with the utilization of the land in Australia, and its relation to the development of rust has not been overlooked. In irrigated areas where wheat was grown, the effect was observed, and it was seen that the judicious application of water was beneficial if done at the right time, and with due regard to atmospheric conditions. There is only one rational method of irrigation for wheat in Victoria, and probably for all Australia, and that is a thorough soaking of the ground prior to ploughing. Mr. Geo. Pagan, of Ardmona, who has successfully irrigated in the Goulburn Valley, states in the *Journal of the Department of Agriculture* for March, 1905, that his routine practice is to flood the land in March, unless there has been heavy rain, and then plough as soon as the horses can work without sinking.

This one watering, followed by proper working of the land, will usually mature the grain. Even in 1902, when the year's rainfall was only six inches, this was the case. The application of water later in the growing season is always risky, and often does more harm than good. It spoils the grain, making it soft, may bring on rust, and results in very uneven ripening.

Seed-bed.—A relatively dry and firm seed-bed is generally considered best for wheat, and especially if there is a prospect of rain after sowing to ensure a good germination. Its effect on rust has not been definitely determined, but farmers are generally of opinion that sowing on a dry seed-bed gives the plant a better chance to escape the rust. If the seed-bed is moist, the condition will be favorable for the rust-spores on the soil, or on the grain, to infect the germinating wheat-plant, but probably it is not so much the nature of the seed-bed as the aftergrowth which will affect the result. This also applies to the mode of sowing, for it did not appear to make any difference, as regards rust, whether the wheat was sown broad-cast or drilled.

Ploughing and Harrowing.—The question of deep as opposed to shallow ploughing does not seem to have much to do with the rust. In experimental tests, deep ploughing yielded the heavier crop, and thus indirectly favoured the development of rust; but both were about equally affected. Harrowing when the crop was about two feet high was equally inconclusive.

Rotation.—Rotation is undoubtedly good for the crop, and is a factor in clean cultivation; but it is another question whether it is good or bad for

the rust. At Port Fairy, in Victoria, where rotation is regularly practised, and where I have had crops grown the same season, sometimes after mangels, or potatoes, or onions, there was no perceptible difference in rustiness from those crops of wheat grown in succession. From the stand-point of good farming, it is to be recommended; but cropping year after year does not seem to affect the liability to rust further than this, that self-sown wheat is likely to appear in the interval between the two crops. Such "volunteer" wheat, if not killed in cultivating, is much more forward than sown grain, and on account of its earliness may escape the rust, but on the other hand, there is a risk attending it, for it is sometimes more rusty than the ordinary wheat, and appears earlier, so that it is one of the means of carrying over the rust from one season to another. All such wheat should therefore be kept down by means of sheep.

Fallowing.—This practice is similar in its effects to rotation as regards rust. Professor Lowrie, speaking from a large experience in South Australia, considers that the apparent exemption which fallow-land sometimes enjoys from rust is due to the fact that it is customary to sow bare fallow-land first, and the crop ripens sufficiently early to escape the rust in some seasons.

Burning Stubble.—It is sometimes recommended to burn the stubble in order to destroy any spores of rust that may be about; but as a matter of experience, this has not been found to produce any appreciable difference. Theoretically, the burning of the surface of the soil should destroy a number of spores, and to that extent is beneficial; but, practically, the difference in result is not marked. As far as most wheat-soils are concerned here, the loss of vegetable matter is much more serious than any possible increase of rust.

Soils.—Soils are sometimes said to be rust-labile and rust-free, like the wheat itself; but on closer investigation, it will be found that the soil is only one of several factors that require to be taken into consideration. Rich soils are said to suffer most, and in rusty years the best crops have sometimes been raised from the poorest soils. On the rich soils the crop is naturally heavier and more luxuriant than on poor soils, and the softer and more susceptible tissues are easily invaded by the parasite. Hence it is that the rust may sometimes be worst in the best crops. The mallee, in Victoria, is said to be particularly rust-free; but in some seasons the crop has to be cut for hay, in order to save it from being completely destroyed by rust. The reason for general freedom from rust lies not so much in the soil as in the light rainfall and the early ripening of the crop. But if "muggy" weather should prevail when the wheat is flowering, then the crop is just as liable to rust here as elsewhere. At Port Fairy the low-lying black soils more readily produce a rusty crop than the sandy soils, and this may be partly due to the fact that the dark-coloured soils absorb more heat, and are more likely to preserve the spores in a fit state for germination, or because they grow a heavier crop, which often lodges and thus encourages the rust.

Manures.—Perhaps no means for the prevention of rust have been more thoroughly and continuously tested than the application of different manures. In all the States, as well as in New Zealand, experiments have been conducted to this end, and the general opinion has been expressed by a late Director of Lincoln College, New Zealand:—"No manure has yet been discovered that is a preventative of rust in cereal crops." The tests were carried out under varying conditions, and, as might be expected, the results of one year were often contradicted by those of the next; still, it was generally found that nitrogenous manures favoured the rust, while phosphatic ones had a tendency to diminish it. Nitrogenous manures

tend to increase the amount of flag, and retard ripening, by affording an excess of nitrogenous food, whereas phosphate of lime tends to induce early maturity, and thus enables the crop to escape the rust to a certain extent.

Treatment of Seed.—This was thoroughly gone into, since it is so often stated that the disease is in the seed. No doubt appropriate treatment destroys the spores entangled in the "brush," but inside the seed no mycelium has been traced. A great variety of "steeps" have been used, and I have myself experimented with over twenty, including the hot-water treatment; but they were all of no practical benefit. Last season (1904) two plots of Queen's Jubilee wheat were sown the same day and grown alongside of each other, in one of which the seed was treated with formalin, while the other was untreated. The rust was bad on both plots, and although special attention was given to the matter in the field, I could not say that treatment of the seed with formalin gave any advantage as regards rust.

Both sulphate of copper and formalin destroy the rust spores on the seed-grains, and Dr. Hollrung, as the result of a series of experiments, has recommended the latter as the best for this purpose. But since infection chiefly takes place when the wheat plant is above ground, it is evident that the formalin treatment does not prevent it, and the experience of numerous farmers who have used formalin successfully for the treatment of stinking smut (*Tilletia tritici*), bears this out.

The hot-water treatment of the seed is constantly being brought forward as a remedy for rust, but in 1892 the seed for 118 plots, consisting of different varieties of wheat, was treated with hot water at 55 deg. C., and in some cases the rust was just as bad as if no treatment had been given.

It was adopted as a conclusion at the last Rust-in-Wheat Conference that the treatment of the seed is valueless for rust, and Dr. Cobb¹⁰ one of the representatives of New South Wales, went so far as to say:—"As for curing rust by treating the seed, the idea is ridiculous. It would be just as reasonable to expect to prevent measles among mankind by soaking babies in some sort of pickle."

It has not been thought necessary to refer specially to spraying as a means of combating the rust; for although this method is practicable in an orchard, and has been found successful in treating peach and plum rust, still the mechanical difficulties to be overcome in spraying a wheat-field are so great, that it is no longer regarded as of practical importance.

So far it would seem as if the rust in wheat defied treatment, and the only practical measures to be recommended for mitigating its effects were to sow early and to select early maturing varieties. In this way it is often possible to escape the rust, or the crop is too far advanced to suffer seriously. But in this, one is at the mercy of the weather, and the only hopeful remedy is to grow wheats which will be able successfully to resist the rust, even when the weather favours its development.

The question has been raised as to whether a wheat which resists one kind of rust can succumb to another in a different country, and this has really been found to be the case. Professor Eriksson sent me ten varieties of Swedish wheats which had been grown in the experimental plots, and found to resist the rust which is prevalent in that part of the world, viz., Golden Rust (*Puccinia glumarum*). When grown here these rust-resisting Swedish wheats became rotten with rust, although of a different kind; and this, along with other experiments, points to the possibility that a wheat may resist a rust such as *P. graminis* in one country and succumb to it in another.

Selection and Cross-breeding. — As the result of numerous experiments, and the trial of hundreds of varieties of wheat from all parts

of the world (Europe, Asia, Africa, and America), it has been proved that no wheat is absolutely rust-proof, that is to say, there is no wheat known which will be proof against the rust when grown under conditions favorable to its development. But the same experiments have shown that among a number of varieties grown in a particular district, some will resist the rust more than others, are able by their constitution—it may be by their vigour of growth or toughness of their cuticle or glaucousness, or all combined—to resist the inroads of the rust sufficiently to prevent its seriously injuring the grain, and such wheats are known as rust-resisting wheats. At present we have at least one such wheat which has been grown in various districts of different States alongside of other wheats badly rusted, and it has been able to withstand the rust. Rerraf is the wheat referred to, and perhaps it, too, in course of time, will succumb to the rust.

For this great and burning rust-question the only measures I can suggest are:—

1. To produce wheats suited to our Australian conditions by crossing, as Mr. Farrer, Wheat Experimentalist of New South Wales, is now so successfully doing.

2. To select and carefully cultivate the most rust-resisting plants from these and other wheats having the necessary hardy, prolific, grain-holding, and milling qualities, keeping up the strain and constantly renewing their constitutional vigour.

3. To cultivate early maturing varieties and sow them early, combined with the best agricultural methods, such as clean cultivation, judicious rotation, suitable (phosphatic) manuring and fallowing, to insure a good crop.

In judicious crossing and careful selecting lies the solution of the great rust problem, as far as our present knowledge goes, and to increase and extend this knowledge it would be desirable to follow the advice of Professor Eriksson, who has done more than any other single individual to enlighten us on the subject:—"The question of the rust of cereals being of the greatest practical importance for every country, means should be furnished to those in whose hands the direction of these investigations are placed, to meet from time to time, that is to say, at least every five years, in order to discuss, according as experience is gained, the value of any new observations, and to gain for their work the advantage of being based on a plan common in its essentials to all."

Rust in wheat has been known in Australia for at least 80 years. H. C. L. Anderson, Principal Librarian of the Public Library of New South Wales, informs me that the earliest record of it is given by Atkinson,¹ who, referring to 1825, or even earlier, says that "rust sometimes appears, but it is not very common." J. Montague Smith, in 1828, notes that the plains and forest lands of the Hunter district of New South Wales suffered from rust in wheat. As the wheat-growing area extended, the rust also spread with amazing rapidity, until now it is undoubtedly the most widely distributed and the most destructive of all the diseases to which cereals are subject.

NOTE 1.

P. 4.—Eriksson¹⁸, in his latest work on the vegetative life of *Puccinia graminis*, has described and figured a transition from the mycoplasm to the protomycelial stage, but it still remains to be seen how far his interpretation of the facts is borne out by other observers.

NOTE 2.

P. 14. —Christman¹, however, has clearly shown that two fertile cells or swollen hyphal branches come into contact, and at the point of contact an opening is formed by solution of the cell wall, and thus their contents mix although the nuclei do not fuse. There is thus true sexual cell fusion without the intervention of spermatia.

NOTE 3.

P. 24.—Arthur⁸ considers the sorus in such species as *Puccinia bromina* and *P. triticea* to be compound and the modified hyphae which separate the individual sori to form a stroma, hence they are not paraphyses, strictly speaking.

NOTE 4.

P. 37.—The origin of the aecidiospores as shown by Christman,¹ from the fusion of sexual cells and the peridium from morphologically equivalent cells disposes of the view that the aecidiospores may have been derived from teleutospores. If, as Blackman suggests, the rusts originated from the red algae, then the sexual product or aecidium would represent an early stage in the history of the Rusts.

NOTE 5.

P. 43.—Hooker, in his classical essay *On the Flora of Australia* (1859), has a chapter on some of the naturalized plants, showing that even nearly half a century ago, the chick-weed, knot-weed, scarlet pimpernel, daisy, mallow, sweetbrier, and various other common plants had been introduced. The groundsel, however, is not mentioned, and no doubt as trade increased with other countries and exchange of products took place, the importation of the seeds of weeds became common.

NOTE 6.

P. 62.—Beauverie¹ has experimented with *Botrytis cinerea*, or grey rot, and obtained, in sterilised soil, an attenuated form of fungus. He infected soil liberally with this form, and grew plants therein from seeds and cuttings perfectly free from the fungus, while plants not rendered immune in this way perished.

NOTE 7.

P. 68.—Kirk informs me by letter what he has already stated in his Annual Reports that "Barberries are being largely used in New Zealand for hedges, and, up to the present, I have never seen any sign of aecidia of *Puccinia graminis* on them, although I have examined hundreds. It would appear as if *Puccinia graminis* in Australia has lost the power of forming aecidia on barberries."

NOTE 8.

P. 69.—Bolley,⁵ however, has announced that he found the uredospores of *Puccinia graminis* successfully surviving upon dead leaves and straw, even retaining their vitality when exposed to the drying winds of autumn, and the intense cold of winter.

PART SECOND.

CLASSIFICATION AND TECHNICAL
DESCRIPTIONS.

CHAPTER XX.

CLASSIFICATION, WITH SPECIAL REFERENCE TO BIOLOGIC FORMS.

Our views as to the limits of species have undergone a change owing to the results of infection experiments in the rusts as well as in other groups of fungi. Species have hitherto been distinguished on morphological grounds, those possessing the same structural characters being considered identical, and separated from those which differ from them in essential points. But in recent times, when infection experiments have been carried out on an extensive scale, it has been found that parasitic fungi, completely agreeing in structural characters, or at least differing so slightly as to be incapable of separation, have very different infective powers. It has therefore become necessary to recognise such forms, and since the differences are based upon physiological or biological characters, they will be distinguished as "biologic forms." Various names have been proposed for these different varieties, such as "special forms," by Eriksson; "biological species," by Rostrup; "sister species," by Schroeter; and "adapted races," by Magnus.

The truly morphological species, such as *Puccinia graminis*, Pers. or *Erysiphe graminis*, DC., have still to be recognised; but each one may be split up into a number of different forms, with distinct powers of infection.

GRADATIONS OF SPECIFIC VARIATION.

There is every possible gradation, however, between species which are morphologically distinct and those which can only be separated on biologic grounds. *Puccinia graminis* Pers., for instance, is recognised as an independent species, because all the forms of this rust produce aecidia on the barberry (except where it has lost this power), and the structural characters are always practically the same. It is regarded by Eriksson as a collective species, in which the different members are so closely related, both morphologically and biologically, that they are only separable into biologic forms, and not to be distinguished as species. The forms on the different hosts are not identical, but they constitute a series, each member of which runs its course on definite host-plants, and is more or less strictly confined to them. Arranged according to the principal host-plants they are as follows:—1, secalis; 2, avenae; 3, airae; 4, agrostidis; 5, poae; 6, tritici.

The collective species known as *Puccinia rubigo-vera* (DC.) Wint. was first divided in 1894 by Eriksson and Hennig¹ into the two distinct species of *P. glumarum* (Schum.) Eriks., the Yellow Rust, and *P. dispersa*, Eriks. and Henn. the Brown rust. *P. glumarum* has not been found in Australia, and it is not necessary here to refer to the various biologic forms into which it has been divided. No aecidial stage has been found in connexion with it.

P. dispersa, when first separated from *P. glumarum*, was split up into four biologic forms by Eriksson, since he did not at that time consider them sufficiently distinct to be designated species. These forms were:—1, secalis; 2, tritici; 3, bromi; 4, agropyri. Further investigation, however, led him in 1899 to raise the various biologic forms to the rank of independent species, and it will be interesting from our present standpoint to consider the reasons given by Eriksson for differentiating between

the biologic forms of *P. dispersa* and those of *P. graminis*. The name of *P. dispersa* Eriks., was reserved for the form on rye, and it is separated from that on wheat, for example, on the following grounds:—

1. The uredo is only able to infect the host-plant, *Secale*.
2. This form regularly appears several weeks earlier than that on wheat, even when the host-plants are growing alongside of each other.
3. The aecidiospores on *Anchusa* spp. only infect *Secale*, and the teleutospores of this form can in turn only produce the aecidia on *Anchusa*.
4. The teleutospores are only capable of germination immediately after they are formed, while those of the others only germinate in the following spring.

It will be observed that these are only biological or physiological differences, but in the two species recognised by Eriksson which occur in Australia, viz., *P. triticina* and *P. bromina*, there are also structural differences sufficient to separate them apart from other considerations. In *P. bromina* the uredo-sori are much larger, and the bright orange uredospores are also slightly larger. It is in the teleutospores, however, that the difference is most striking, and those of *P. triticina* are much narrower, only being about three-fourths that of the other.

P. hieracii (Schum.) Mart., as at first constituted, was a collective species, but, like so many others, when the test of infective power is applied to them, it had to be broken up into several. It has been proved by Jacky¹ that the common *Puccinia* occurring on species of *Hieracium* can only infect this, and not other genera of Composites, so that the original name is restricted to the species found on this genus. Other species of *Puccinia* occur on *Hieracium*, but they are readily distinguished by their different morphological characters. Similar results have been obtained with *Puccinias* occurring on other genera, so that they also must be regarded as distinct species.

It will be observed that only biological characters are here taken into account, depending on the nature of the host-plant, but it is believed that the closer and more careful investigation now rendered necessary will result in structural differences being found, possibly of a more minute and less striking character than formerly, where they were hitherto unsuspected and overlooked.

The three types selected for illustration will show the spirit of our classification.

P. graminis is the type of a single species which is split up into a number of biologic forms, agreeing in the fact of producing aecidia on the barberry, and the aecidiospores in turn infect the grasses.

P. dispersa, as originally constituted, is the type of a collective species at first divided into biologic forms, which were afterwards found to be distinct species, both on morphologic and biologic grounds. And the original *P. hieracii* is the type of a collective species, the members of which are strictly limited in their infective power to single genera, and their main title to distinction as species is this biological peculiarity.

The phenomenon of specialisation, first discovered by Eriksson, has thus caused us to revise our conceptions of species, and it will be necessary in the future not only to include under that name such forms as possess distinct morphological characters, but also those which, although morphologically similar, are yet confined to definite host-plants. It will thus be necessary to split up the old species of *P. hieracii* into several of equal rank, and the one growing on *Hieracium* spp. will form a type round which the others may be grouped. Just as in the old species there were differences of opinion as to the amount of structural differentiation necessary to separate

two allied forms, so in the new there is the same difficulty with the biological characters, but it may be laid down, as a general rule, that the sharper the distinction between two biologically different forms, the greater the reason for calling them species, while the less distinctly marked would be called biologic forms. It is all a matter of degree, and it must be left to the good tact of the investigator, as Klebahn says, where to draw the line between species and biologic forms.

Among the heteroecious rusts, there may be structural resemblances between one generation and differences in the other. In that case, as a matter of convenience, if the differences in the one generation are sufficiently distinct, such should be designated species.

Biologic forms, in fact, may be regarded as incipient morphological species, the physiological differences at present existing becoming ultimately associated with morphological distinctions, which will mark them off as true species. It is not easy to explain how this has come about, but we may be sure that the explanation is to be sought, not along one line, but along various converging lines.

The biologic forms of one and the same morphological species, such as *Puccinia graminis*, may be supposed to have had a common origin, and the most probable view is that the original form inhabited all the hosts on which its descendants now live, and some of these descendants specialised on one or other of these common host-plants. What caused them thus to specialise? It may have been either through gradually becoming adapted to certain of these host-plants in preference to others, or due to a spontaneous change arising from internal causes, as expressed in the mutation theory of De Vries.

This is Fischer's⁴ view, and Klebahn¹, after examining the evidence, sums up as follows:—"The manifold characters of the existing biological species and races appear to have come about owing to the alternating extensions and restrictions of the area of nutritive plants. These changes, and especially the restrictions of area, have been influenced by adaptation and selection, but many observations indicate that internal developmental tendencies have also played a part in determining the direction of the evolution."

The whole trend of this modern investigation is towards the recognition of more deep-seated characters in the discrimination of species. One parasite has become so thoroughly adapted to the physiological characters of a host-plant that it cannot infect another, and so the plant on which the parasite lives becomes a diagnostic feature of it. It is so much easier, and has been so long the custom to be guided by morphological characters alone, that physiological distinctions are not readily accepted, but now that they are known, they must be recognised in some way, and the most convenient is to incorporate them in the specific characters.

Again, the different stages of a fungus require to be known, in order to classify it properly, and the mere knowledge of the uredo or aecidial stage will not suffice for this purpose. Hence the life-history and infective power, as well as structural characters, must all be taken into account in fixing and determining species.

CHAPTER XXI.

SYSTEMATIC ARRANGEMENT AND TECHNICAL DESCRIPTIONS.

The different Rusts found in Australia are here named, described, and systematically arranged. The names are necessary to distinguish one from another, for, as George Eliot happily puts it—"The mere fact of naming an object tends to give definiteness to our conception of it. We have then a sign which at once calls up in our minds the distinctive qualities which mark out for us that particular object from all others." The descriptions are necessarily technical, and give those characters which enable the species to be discriminated from others, with the help of the illustrations. When the described stage of any rust is enclosed in square brackets, this indicates that it has not been found in Australia. The systematic arrangement deals with the nine genera at present known, and arranges them according to their natural affinities. Taking a general view of the entire order, the following scheme of classification will be adopted, mainly based upon that of Engler and Prantl, in their *Die natürlichen Pflanzenfamilien*:—

Order—UREDINEAE, Tul.

Fungi parasitic on higher plants and developing in the interior of their hosts, a filiform, branching, septate mycelium. Spores arising terminally or laterally from erect, transversely divided, crowded hyphae, and usually of more than one kind. Teleutospores germinating by a short promycelium. The order may be grouped in the following four families, of which the third is not represented in Australia:—

Teleutospores stalked, single, in groups or rows, or several cells in a head. Fam. 1. Pucciniaceae.

Teleutospores sessile, in columnar or filiform masses. Fam. 2. Cronartiaceae.

Teleutospores sessile or stalked, in one or two-layered waxy masses. Fam. 3. Coleosporiaceae.

Teleutospores sessile, in flattened one-layered masses, or loose in the tissues of their host. Fam. 4. Melampsoraceae.

On account of their economic importance, the Gramineaceous rusts are always treated first and the others are likewise grouped together under their respective families of host-plants, the order generally followed being that of Baron von Mueller's *Systematic Census of Australian Plants*, starting from the Grasses, and ascending to the higher forms.

FAM. 1. PUCCINIACEAE.

Since the great majority of our Australian Rusts belong to this family, it will be treated at greater length than any of the others, and it will be interesting to trace the different forms which the teleutospore assumes in the different genera. There are a number of genera based upon very slight differentiating characters, and it is not always easy to settle whether they should be retained or rejected, but I have given all those which are clearly distinct. It is a moot point whether such a genus as *Diorchidium* Kalch. should be retained, where the teleutospore is two-celled, as in *Puccinia*, only the septum is longitudinal instead of transverse. There are several species of *Puccinia* in which there is a tendency to an oblique, and even a longitudinal septum, as well as transverse, but this genus is retained for those species in which the spore is distinctly divided longitudinally with a single germ-pore at the apex of each.

From a consideration of the distribution of the Uredineae on their host-plants, Dietel¹² has come to the conclusion that the genus *Uredinopsis*, belonging to the Melampsoraceae, and occurring on ferns, represents the oldest type of the Rusts, and that the Pucciniaceae may have developed from the genus *Melampsora*. However that may be, we may assume that the primitive form of this family was one-celled, and therefore the *Uromyces* type forms the starting-point; also that the transition from the one-celled to the two-celled spore as in *Puccinia*, was the next step in advance.

The actual evidence of this transition is seen not only in *Puccinia heterospora*, B. and C., where the two-celled spore has not yet become completely established, being mixed with a large number of unicellular spores, but in such forms as *Uromyces vesiculosus*, where there are occasional two-celled spores, Fig. 157, *U. tricorynes*, Fig. 134, and *U. politus*, Fig. 317.

Both *Uromyces* and *Puccinia* species occur on plants of the most diverse character, and this would seem to indicate that many of the species came into existence before that specialisation had begun, which resulted in the genus *Phragmidium*, for instance, confining itself to the Rosaceae.

The principal genera are here arranged according to the nature of the teleutospore, and the diagrammatic representation of the spores will show at a glance the peculiarities of each:—

1. *Uromyces*, Link.—Teleutospore one-celled, with single germ-pore, and solitary on its stalk. Uredospores echinulate or warty all over. Fig. 16.
2. *Hemileia*, Berk and Br.—Teleutospore one-celled as in *Uromyces*, but uredospore smooth on one face.
3. *Uromycladium*, McAlp.—Teleutospore one-celled as in *Uromyces*, but the sporophore branching toward the apex produces either one spore with a colourless sterile spore or cyst, or two or more spores with or without a cyst. Fig. 17.
4. *Puccinia*, Pers.—Teleutospore two-celled, with transverse septum and with only one germ-pore in each cell. Fig. 18.
5. *Gymnoconia*, Lag.—Teleutospore as in *Puccinia*, but aecidia without pseudoperidia.
6. *Uropyxis*, Schroet.—Teleutospore bicellular as in *Puccinia*, but each cell with two or more germ-pores, and the teleutospore membrane consisting of more than two layers. Fig. 19.
7. *Diorchidium*, Kalch.—Teleutospore two-celled, with longitudinal septum and germ-pore at apex of each cell. Fig. 20.



FIG. 16.



FIG. 17.



FIG. 18.



FIG. 19.



FIG. 20.

8. *Gymnosporangium*, Hedw.—Teleutospore two-celled (rarely three to five celled), and walls which ultimately form a common gelatinous mass, with usually several germ-pores in each cell. Fig. 21.
9. *Haplophragmium*, Syd.—Teleutospore three celled, and consisting of two basal cells alongside of each other, with a third on top. Fig. 22.
10. *Triphragmium*, Link.—Teleutospore three-celled, and consisting of basal cell supporting two others alongside of each other. Fig. 23.

11. *Phragmopyxis*, Diet.—Teleutospore three-celled in a longitudinal series, with outer layer swelling when moistened. Fig. 24.
 12. *Phragmidium*, Link.—Teleutospore three or more celled in a longitudinal series, and outer layer not swelling when moistened. Fig. 25.



FIG. 21.



FIG. 22.



FIG. 23.



FIG. 24.



FIG. 25.

13. *Sphaerophragmium*, Magn.—Teleutospore consisting of a spherical head of four to nine cells, and arising from a single cell by longitudinal and transverse fission. Fig. 26.
 14. *Anthomyces*, Diet.—Teleutospores forming a head of three to eight cells, borne on a single stalk, and arising from a simple cell by the formation of longitudinal septa. Several small sterile cells at base. Fig. 27.
 15. *Ravenelia*, Berk.—Teleutospores forming a more or less hemispherical, many-celled head, transversely and longitudinally septate, arising from a stalk compounded of several hyphae, and with several sterile cells or cysts at the base. Fig. 28.



FIG. 26.



FIG. 27.



FIG. 28.

Only four of these genera occur in Australia, and they will be dealt with in the following order:—*Uromyces*, *Uromycladium*, *Puccinia*, *Phragmidium*.

UROMYCES Link.

In this genus the teleutospores are unicellular as well as the uredospores, and this has sometimes caused the one to be mistaken for the other, but the single germ-pore in the former serves to distinguish it. Besides, the uredospores are always echinulate or warted, and while the teleutospores are usually smooth, they may also be striated or warted, but the generally greater thickening of the wall, and the fact that the contents are nearly colourless, also serve to separate them. All the different spore-forms may be present in the same host-plant, or they may be reduced to the teleutospore alone. In clover rust (*U. trifolii*) and beet rust (*U. betae*) all the spore-forms occur, but in the latter, although the rust is very common, I have seldom found the aecidia, and Plowright states that the aecidia are very rarely found even in Britain.

Pea rust (*Uromyces pisi*), with its aecidia on *Euphorbia* and its uredospores and teleutospores on the pea, has not been found here, nor any other heteroecious species of this genus.

In carnation rust (*U. caryophyllinus*) only uredo and teleutospores are known, and this grouping of spore-forms is the most common with us. Aecidia and teleutospores occur on the same host-plant in *U. limosellae* and *U. puccinioides*, the uredospores being unknown, and teleutospores alone are found in *U. bulbini* and *U. diploglottidis*. The rusts on clover, beet, and carnation are the best known, and since the carnation is attacked at all stages of its growth, it has suffered considerably from this disease.

General Characters.—Spermogonia mostly globose, immersed, with conical projecting neck.

Aecidia immersed, finally cup-shaped, with well-developed pseudo-peridium; aecidiospores without distinct germ-pores.

Uredospores solitary on their stalks, with several usually distinct germ-pores.

Teleutospores unicellular, pedicellate, only one produced from each sporophore, with a single germ-pore at apex.

Sporidiola hyaline, ovoid, ellipsoid, or almost kidney-shaped.

Australian species, 27.

GRAMINEAE.

Danthonia.

1. *Uromyces danthoniae* McAlp.

- I. Aecidia amphigenous, densely crowded in relatively large clusters, bright orange; pseudoperidia cup-shaped, ivory white, margin regular, upright, very finely toothed, up to $320\ \mu$ in diam.; pseudoperidial cells persistent, elongated and polygonal, with striated margin.

Aecidiospores subglobose to polygonal, orange, average $16\ \mu$ diam. or $16 \times 12\ \mu$.

- II. Uredosori minute, erumpent, somewhat scattered, ruddy brown.

Uredospores pale yellow to orange yellow, broadly elliptical to ovate, finely echinulate, with as many as six scattered germ-pores on one face, $27\text{--}32 \times 23\text{--}26\ \mu$.

- III. Teleutosori chocolate brown to black, elongated, running in lines, long covered by epidermis.

Teleutospores at first intermixed with uredospores, pear-shaped to ovate or broadly fusiform, smooth, with thickened apex, $30\text{--}41 \times 20\text{--}26\ \mu$, average $33 \times 22\ \mu$; pedicels elongated, persistent, slightly tinted adjoining spore, up to $96\ \mu$ long.

I. on leaves of *Danthonia* sp. II., III. on leaves of *Danthonia semiannularis* R. Br.

Victoria—Bacchus Marsh, I. Near Melbourne, Ardmona, Portland, Killara, Leongatha, Rutherglen, Nagambie, Kergunyah, &c., II., III.

Tasmania—Domain, Hobart, Nov., 1894, II., III. (Rodway).

The acidium found on a species of *Danthonia* at Bacchus Marsh is described in connexion with this species as a matter of convenience.

Puccinia graminella (Speg.) Diet. and Holw., occurring on a species of *Stipa* in Argentine, Chili, and California, is the only instance hitherto known where the acidium-stage is found on a grass. Teleutospores are developed on the same mycelium alongside of the aecidia, and compressing them on either side.

The aecidia are described as follows:—"Epiphyllous, and arranged loosely in interrupted lines; pseudoperidia persistent, composed of oblong cells, with margin irregular and lacerated. Aecidiospores elliptic or ovoid, $21-29 \times 18-21 \mu$."

The aecidia on *Danthonia* are quite distinct. They occur on both surfaces of the leaf, are arranged in dense clusters, the margin of the pseudoperidium is regular and very finely toothed, and the aecidiospores are considerably smaller.

There is a good deal of confusion over the species of *Danthonia* in Australia, and they probably require to be dealt with by a specialist. The late Baron von Mueller, in his Census, included *D. pallida* R. Br., *D. semiannularis* R. Br., *D. pilosa* R. Br., &c., under *D. penicillata* F.v.M. Following the *Index Kewensis*, these three species will be retained, but *D. penicillata* F.v.M., will be regarded as a synonym.

Darlucalium Cast., is common on uredosori.

(Plate XVI., Fig. 131; Plate J.)

Ehrharta.

2. *Uromyces ehrhartae* McAlp.

McAlpine, Agr. Gaz. N.S.W., VI., p. 855 (1895).

Sacc. Syll. XIV., p. 405 (1899).

Uredo ehrhartae McAlp.

- II. Uredosori on both surfaces of leaves and on sheath, minute, oval to elongated linear, sometimes confluent, at first covered then naked, yellowish-brown to orange.

Uredospores subglobose to oval, orange, finely echinulate, 3-4 scattered germ-pores on one face, $21-25 \times 18-20 \mu$, average $24 \times 19 \mu$.

- III. Teleutosori similar, up to 1 mm. long, confluent in lines, chocolate brown to black.

Teleutospores pale chocolate brown to chestnut brown, only occasional uredospores intermixed, hooded and thickened at apex ($8-9 \mu$), and either conical or truncate, very variable in shape and size, elongated or short and stout, subglobose to elliptic, fusiform or oblong, $19-32 \times 13-19 \mu$, average $26 \times 15 \mu$; pedicels persistent, tinted, elongated, up to 45μ long.

On *Ehrharta stipoides* Labill. = *Microlaena stipoides* R. Br.

Victoria—Near Melbourne, Killara, Myrniong, Kergunyah, &c., June-March.

Uredospores common but teleutospores rather sparse, although in the neighbourhood of Melbourne during December and January the teleutosori are sometimes rather common, usually on the lower withered leaves, and intermixed with uredosori on those still partially green. Only the uredo-stage was found at first by Mr. Robinson, but latterly at Killara, in March, and Kergunyah, in November, he secured the teleutospores.

Darlucalium Cast., is very common on uredosori.

(Plate XVI., Fig. 132.)

Sporobolus.3. *Uromyces tenuicutis* McAlp.

- II. Uredosori on both surfaces of leaves, but mostly on upper, and on stems, elliptic to oblong, orange-yellow, pulvinate, generally minute, but may reach a length of 1 mm., at first covered by epidermis, then erumpent, pulverulent.

Uredospores orange, ellipsoid to ovoid, spinulose, rather large, with two distinct germ-pores on one face, equatorial or nearly so, $28-40 \times 19-24 \mu$, average $32 \times 22 \mu$.

- III. Teleutosori on lower surface of leaf, minute, pulvinate, covered by epidermis.

Teleutospores yellowish-brown, smooth, obovate to oblong or piri-form, irregularly rounded or truncate, or even pointed at apex, and slightly thickened, sometimes broader than long, $22-35 \times 16-25 \mu$, average $28 \times 20 \mu$; pedicel sometimes persistent, usually tinted, commonly $20-35 \mu$ long, but often much shorter.

On leaves and stems of *Sporobolus indicus* R. Br.

Victoria—Near Melbourne, Aug.—March.

U. sporoboli E. and E., found on leaves of *Sporobolus asper* Kunth, in the United States, has no uredo-stage, and the teleutosori are soon naked, while the teleutospores may be subglobose and provided with long pedicels.

Darlucal filum Cast., is very commonly associated with the uredospores.

(Plate XVI., Fig. 133.)

LILIACEAE.

Bulbine.4. *Uromyces bulbinis* Thuem.

Thuemen in Flora, p. 410 (1877).

Cooke, Handb. Austr. Fung., p. 409 (1892).

Sacc. Syll. VII., p. 572 (1888).

- III. Sori amphigenous, small, densely gregarious, concentrically disposed in large circles, covered by the epidermis, firm, rather concave, brown.

Teleutospores clavate or oblong clavate, mostly rather acute at the apex, and narrowed at the base, pedicellate, epispore smooth, rather thick, especially at the apex, $30-36 \times 20-22 \mu$; pedicel deciduous, unequal, straight or slightly curved, hyaline to yellowish brown, $12 \times 4 \mu$.

On living leaves of *Bulbine bulbosa* Haw.

Victoria—Omeo (Morrison).

New South Wales—Upper Macquarie River.

Specimen not seen.

Tricoryne.5. *Uromyces tricorynes* McAlp.

McAlpine, Agr. Gaz. N.S.W., VI., p. 756 (1895).

Sacc. Syll. XIV., p. 283 (1899).

- I. Aecidia on pale spots in small clusters, amphigenous; pseudoperidia cup-shaped, with white edges irregularly torn and reflexed.

Aecidiospores bright orange, subglobose to somewhat polygonal, smooth, average $20 \times 17 \mu$.

- II. Uredosori on pale green patches, brick coloured to orange, amphigenous, but more common on under surface of leaves, elongated oval to elliptical, bullate, solitary or in groups, not confluent, at first papillate, then bursting through and surrounded by ruptured epidermis.

Uredospores orange, subspherical to elliptic or ovate, finely echinulate, relatively thick-walled, with two to three germ-pores on one face, average $20-23\ \mu$ diam. or $22-25 \times 19-20\ \mu$.

- III. Teleutosori blackish on ruddy brown spots, elongated and confluent, sometimes completely enveloping stem, at first bullate, finally with greyish epidermis around or over them in shreds and patches, generally 2 mm. long, sometimes up to 3 mm.

Teleutospores variable in form, oval, ovate, or somewhat globular, yellowish-brown to chestnut-brown, smooth, apex thickened (up to $8\ \mu$), round or conical, $25-32 \times 20-29\ \mu$, average $30 \times 25\ \mu$; pedicels persistent, pale yellow, especially towards spore, up to $80\ \mu$ long and $9\ \mu$ broad.

On leaves and stems of *Tricoryne elatior* R. Br.

Victoria—Near Melbourne, Oct., 1892, II., III. (Robinson).

Rutherglen, July, Oct., 1893, I., II., III. Murramurrangbong Ranges, Nov. 1902 (Robinson). Nagambie, Nov., 1904, II., III.

New South Wales—Richmond, Oct. (Musson).

I. on both surfaces of leaves, July. II., on stems and leaves, not very common in July, but prevalent in October and November. III. on stems and branches and both surfaces of faded leaves, very common in July, forming dark swollen patches.

Several two-celled teleutospores occurred, coloured similarly to the ordinary teleutospore and thickened at apex. The spores were constricted at septum, which might be about the middle or towards the base. They were longer than the ordinary spore, and measured about $37 \times 27\ \mu$. The pedicel was occasionally rather lateral.

Darlucal filum Cast., occurred on the uredosori.

(Plate XVI, Figs. 134, 135.)

ORCHIDACEAE.

Microtis.

6. *Uromyces microtidis* Cooke.

Cooke, Grev. XIV., p. 12 (1885).

Cooke, Handb. Austr. Fung., p. 332 (1892).

Sydow, Ann. Myc. I., p. 324 (1903).

Sacc. Syll. VII., p. 579 (1888).

Sori amphigenous, loosely arranged in irregular groups, minute, punctiform, brown, pulverulent, girt by the ruptured epidermis.

- II. Uredospores globose, subglobose, ovate or ellipsoid, minutely aculate to warty, yellowish-brown, $22-30 \times 17-25\ \mu$.

- III. Teleutospores intermixed with uredospores, ovate, with hyaline apiculus, rough with warts, brown, $25-35 \times 17-25\ \mu$, but may reach a length of $41\ \mu$, average $32 \times 24\ \mu$; pedicel very short, hyaline.

On living leaves of *Microtis porrifolia* R. Br.

New South Wales—Bullahdelah, II., III.

Only the teleutospores were described by Cooke, but in a portion of the original material kindly supplied by Massee there were numerous uredospores intermixed with the teleutospores. Sydow ² has also found the uredospores with teleutospores intermixed, on specimens of the same host-plant sent from Chatham Island, New Zealand.

If we compare the three rusts found on the Orchid genera, *Microtis*, *Chiloglottis*, and *Thelymitra*, it is found that aecidia occur on *Chiloglottis*, but are absent, as far as known, from the other two. The teleutospores are all provided with a hyaline apiculus, but in *U. microtidis* the episore is very rough and knobby, and the size of the spore not generally exceeding 35 μ long, while in *U. thelymitrae* the episore is generally thicker, and the spore polygonal and irregularly warted and altogether larger. The rust on *Chiloglottis* generally resembles that on *Microtis*, but the teleutospore is larger.

The following table will show the points of resemblance and difference in the teleutospores :—

	Size.	Episore.	Thickness.	Apiculus.
<i>Uromyces microtidis</i>	25-35 \times 17-25 μ	Generally prominently warted all over	3-4 μ	Generally conoid
<i>U. orchidearum</i>	30-50 \times 19-24 μ	Irregularly warted and warts not so prominent	3-4 μ	Generally conoid
<i>U. thelymitrae</i> ...	35-45 \times 25-30 μ	Less closely but more prominently warted, hence polygonal	5-6 μ	Generally obtuse

(Plate XVI., Fig. 139.)

Chiloglottis.

7. *Uromyces orchidearum* Cke. and Mass.

Cooke and Massee, Grev. XVI., p. 74 (1888).

Cooke, Handb. Austr. Fung., p. 332 (1892).

Morrison, Vict. Nat. XI., p. 90 (1894).

Sacc. Syll. VII., p. 580 (1888).

- I. Aecidia hypophyllous, scattered, cup-shaped; pseudoperidial cells polygonal to wedge or pear-shaped, finely notched, 32-40 μ .

Aecidiospores pale yellow, subglobose to shortly elliptical, verruculose, 16-20 μ or 18-22 \times 15-20 μ .

- II., III. Sori mostly epiphyllous, bullate, at length erumpent, golden-brown.

- II. Uredospores elliptic to ovoid, honey-yellow to golden-yellow, echinulate, with several germ-pores, 26-30 \times 16-20 μ .

- III. Teleutospores at first intermixed with uredospores, old gold colour variable in shape and size, elliptic to ovoid or oblong, with prominent hyaline apiculus (up to 9 μ long), usually with irregularly warted episore, which is 3-4 μ thick and brightly coloured, 30-51 \times 19-24 μ , average 36 \times 21 μ ; pedicel hyaline, attenuated downwards, up to 77 μ long.

On leaves of *Chiloglottis diphylla* R. Br., II., III.

New South Wales—Mt. Victoria (Hamilton).

Victoria—Oakleigh, July, 1894 (Morrison ¹).

Tasmania—Bellerive Swamp, May, 1897 (Rodway ¹).

On *C. gunnii* Lindl., I., II., III.

Victoria—Oakleigh, Aug., 1892 (Morrison).

In the original description of Cooke and Massee only teleutospores are recorded, but uredospores were also obtained from the original material labelled in Cooke's handwriting.

Sometimes there are abnormal elongated teleutospores up to $60\ \mu$ long.

Several bicellular spores were met with similarly coloured to the normal teleutospores, constricted at septum, irregularly warted, with prominent hyaline apiculus, $59 \times 28\ \mu$.

(Plate XVI., Fig. 138 ; Plate XL., Fig. 303.)

Thelymitra.

8. *Uromyces thelymitrae* McAlp.

Sori on leaf and sheath, scattered or gregarious, bullate, ellipsoid, yellowish to brownish, compact, surrounded or almost covered by ruptured epidermis, except for a narrow slit, up to $1\frac{1}{2}$ mm. long.

II. Uredospores ellipsoid to obovate or pear-shaped, golden-yellow, echinulate, with as many as four equatorial germ-pores, $25\text{--}32 \times 18\text{--}21\ \mu$.

III. Teleutospores ellipsoid to oblong, or polygonal, chestnut-brown, relatively thick-walled, irregularly knobby, with hyaline apiculus $35\text{--}45 \times 25\text{--}30\ \mu$, average $36 \times 26\ \mu$; pedicel hyaline, short, deciduous, up to $11\ \mu$ broad adjoining spore.

On *Thelymitra antennifera* Hook. f. and *T. flexuosa* Endl.

Victoria—Near Melbourne, Sep. and Oct. (C. French, jun.).

An aecidial stage has been found in Java, by Raciborski, on *Thelymitra javanica* Blume, but it has probably no connexion with our native species.

(Plate XVI., Figs. 136, 137.)

SCROPHULARIACEAE.

Limosella.

9. *Uromyces limosellae* Ludw.

Ludwig in Dietel, Hedw., XXVIII., p. 182 (1889).

Sacc. Syll. IX., p. 293 (1891).

I. Aecidia amphigenous, scattered or gregarious; pseudoperidia with whitish lacinate margin, not deeply incised.

Aecidiospores round to angular, hyaline, smooth, about $15\ \mu$ diam.

III. Teleutosori mixed with the aecidia, often crowded, long covered by epidermis, pulvinate, dark brown.

Teleutospores obovate, oblong or clavate, rarely round, with yellowish-brown, thick, smooth wall, strongly thickened at apex, and for the most part paler, $32-40 \times 18-22 \mu$; pedicel as long as or shorter than teleutospore.

On leaves of *Limosella aquatica* L.

S. Australia—Kangaroo Island (Tepper).

It differs from *U. scrophulariae* (DC.), to which it is otherwise allied, in the size and colour of the spores.

Dietel observed two bicellular teleutospores among the ordinary ones in a spore layer.

Specimen not seen.

GOODENIACEAE.

Selliera, Scaevola.

10. *Uromyces puccinioides* Berk. and F.v.M.

Berkeley and Mueller, Linn. Journ. XIII., p. 173 (1872).

Cooke, Handb. Austr. Fung., p. 332 (1892).

Sacc. Syll. VII., p. 585 (1888).

I. Aecidia aggregate, on brown orbicular spots, arranged in a circinate manner, opposite; pseudoperidia with abbreviated margin.

Aecidiospores orange, subglobose, $16-19 \times 13-16 \mu$.

III. Teleutostori bullate, intermixed with aecidia or surrounding them as a ring, at first covered with greyish glistening epidermis; finally naked.

Teleutospores brown, apiculate, sometimes with the apex oblique or dentate, also thickened and rounded or flattened, $40-44 \times 18-23 \mu$, average $41 \times 22 \mu$; pedicels hyaline, persistent, up to 48μ long.

On leaves and flower stalks of *Selliera radicans* Cav.

Victoria—Near Melbourne, Nov.—June. Wimmera Flats, May, 1897 (Reader). Phillip Island, Jan., 1900. Portland, Jan., 1901. Point Cook, May, 1902 (C. French, jun.). Sandringham, Nov., 1905 (Robinson).

South Australia—Glenelg (Holdfast Bay), 1854 (Berkeley²).

Tasmania—Bellerive Swamp, Dec., 1890, and May, 1897 (Rodway¹).

On *Scaevola* sp.

Queensland—St. George (Wedd) (Bailey¹³).

It is recorded in Cooke's Handbook as being found on *Goodenia*, but there are no certain indications of this. It occurred on *Goodenia herpystica* Schlecht., which, however, is a synonym of *Selliera radicans*.

(Plate XVII., Fig. 140.)

RUBIACEAE.

Asperula.

11. *Uromyces asperulae* McAlp.

McAlpine, Agr. Gaz., N.S.W., VI., p. 851 (1895).

Sacc. Syll. XIV., p. 276 (1899).

II. Uredosori hypophyllous, minute, bullate, bursting through epidermis.

Uredospores globose, subglobose or ovate, finely echinulate, orange-yellow, single germ-pore visible on one face, $21-25 \times 20-21 \mu$.

- III. Teleutosori on stems towards their base, elongated oval, dark-brown, appearing almost black, confluent, erumpent.

Teleutospores at first intermixed with uredospores, yellowish-brown to chestnut-brown, smooth, oval to ovate, or elliptical to broadly clavate, apex much thickened ($11\ \mu$) and rounded, sometimes tapering or flattened, $27\text{--}37 \times 15\text{--}19\ \mu$, average $30 \times 18\ \mu$; pedicels long, persistent, hyaline, up to $45\ \mu$ long.

On stems and leaves of *Asperula oligantha* F.v.M.

Victoria—Ardmona, May to Oct., and in moist places all the year round (Robinson).

The host-plant is given as *Asperula scoparia* Hook. f., in the *Index Kewensis*, but the synonymy seems a little confused. *A. oligantha* F.v.M. is first given as *Rubia syrticola* Miq., then *R. syrticola* is given as a synonym of *Asperula scoparia* Hook. f.

(Plate XVII., Fig. 141.)

LEGUMINOSAE.

Vigna.

12. *Uromyces appendiculatus* (Pers.) Link.

Link, Obs. II., p. 28 (1825).

Sacc. Syll. VII., p. 535 (1888).

Uromyces phaseoli (Pers.) Wint.

[O. Spermogonia on minute spots, whitish.]

- [I. Aecidia densely crowded in small annular groups; pseudoperidia shortly cylindrical, whitish, with deeply cut reflexed margins.

Aecidiospores polygonal, finely warted, colourless, $17\text{--}32 \times 14\text{--}23\ \mu$.]

- II. Uredosori on both surfaces of leaf, round, pale cinnamon brown, pulverulent, solitary or crowded and confluent, soon naked and surrounded by ruptured epidermis.

Uredospores yellowish brown, ellipsoid to ovate, finely echinulate, $23\text{--}32 \times 17\text{--}22\ \mu$.

- III. Teleutosori dark-brown, almost black, easily detached, otherwise like uredosori.

Teleutospores dark brown to chestnut brown, subglobose to ellipsoid or oblong, smooth, scarcely thickened at apex, with broad pale flattened papilla, $27\text{--}37 \times 19\text{--}25\ \mu$; pedicel hyaline, persistent, elongated, up to $70\ \mu$ long.

On Cowpea (*Vigna catjang* Walp.).

New South Wales.—Richmond, May, 1905 (Musson).

The distinction between the teleutospores of *U. fabae* and *U. appendiculatus* is very marked. In the one the apex is thickened up to $9\ \mu$, while in the other the thickening is not perceptible.

(Plate XLII., Fig. 306.)

Acacia.

13. *Uromyces bicinctus* McAlp.

II., III. Sori ruddy-brown, gregarious often confluent, raised, compact, rupturing epidermis irregularly.

II. Uredospores yellowish-brown, clavate to oval or ellipsoid, rounded at apex and slightly thickened, densely warted and warts arranged in regular longitudinal lines, with distinct germ-pores, generally arranged in two bands about one-third length of spore from either end, and usually three to four in each band on one face, $30-40 \times 13-18 \mu$, occasionally reaching a length of 45μ , and variable in breadth, average $34 \times 15 \mu$; pedicel similarly coloured to spore or paler.

III. Teleutospores intermixed with uredospores, pallid but thickened considerably at apex and brown ($8-11 \mu$), smooth, ellipsoid, and rounded at both ends, occasionally prolonged into one or two processes at apex, $28-34 \times 17-23 \mu$; pedicel persistent, hyaline, short.

On phyllodes and pods of *Acacia fasciculifera* F.v.M.

Queensland—Rockhampton, 1867 (from host-plant in National Herbarium, Melbourne).

This species approaches somewhat to *U. phyllodiorum* (B. and Br.), McAlp., in the uredospores, but they are shorter and much narrower, and distinguished at once by the two bands of germ-pores, on account of which the specific name is given. The teleutospores are also much thickened at apex and destitute of processes as a rule, although occasionally two may appear.

(Plate XLIII., Fig. 318.)

Vicia.

14. *Uromyces fabae* (Pers.) De Bary.

De Bary, Ann. Sci. Nat. Ser. 4, XX. (1863).

Sacc. Syll. VII., p. 531 (1888).

[O. Spermogonia yellowish, in small groups on leaves and stem.]

[I. Aecidia scattered, in rings or orbicular patches; pseudoperidia short, slightly prominent, flat, with torn white edges.

Aecidiospores subglobose, orange, finely echinulate, $16-26 \mu$ diam.]

II. Uredosori amphigenous, roundish, pale brown, powdered, scattered, often confluent, soon naked.

Uredospores subglobose or ovate, ochraceous, echinulate, with three equatorial germ-pores on one face, $20-30 \times 17-20 \mu$.

[III. Teleutosori rounded on the leaves, more abundant and elongated on the stems, often confluent, blackish-brown.

Teleutospores variable in form, obovate or broadly clavate, smooth, dark-brown, apex darker, thickened ($8-10 \mu$), and rounded, truncated or conical, sometimes with colorless papilla, $24-47 \times 17-30 \mu$; pedicels hyaline or pale brown towards spore, persistent, up to 110μ long.]

On stems, leaves, and pods of Broad Bean (*Vicia faba* L.).

New South Wales.—1894 (Cobb³).

Queensland.—Gladfield (Gwyther) (Bailey¹⁹).

This rust has not been found in Victoria, and although it is said to be very common in New South Wales, on applying to Dr. Cobb for specimens, he informed me that they had all been destroyed by insects. Only the uredo-stage was found in New South Wales, and the exact species is still doubtful.

(Plate XLII., Fig. 307.)

Acacia.

15. *Uromyces fusisporus* Cke. and Mass.

Cooke and Massee, Grev. XVI., p. 2 (1887).

Cooke, Handb. Austr. Fung., p. 331 (1892).

Sacc. Syll. VII., p. 555 (1888).

Sori amphigenous, solitary or in groups and then confluent, elliptic to discoid, dark-brown or black, erumpent and girt by the ruptured epidermis.

II. Uredospores golden-brown, fusiform, obtusely warted, with acute and more or less hyaline apiculus, 3-4 equatorial germ-pores on one face, $57-77 \times 17-25 \mu$, average $62 \times 23 \mu$.

III. Teleutospores intermixed with uredospores, ruddy brown, globose to depressed globose, epispore rather thin, scarcely 2μ thick, somewhat polygonal seen from above and then germ-pore very prominent, $25-30 \mu$ diam. or $16-21 \times 25-35 \mu$, average $18 \times 28 \mu$; pedicels deciduous, hyaline, elongated, up to 96μ long, with septum at a short distance beneath spore.

On phyllodes of *Acacia salicina* Lindl., and *A. neriifolia* A. Cunn. = *A. retinodes* Schlecht.

Victoria—Dimboola, Dec., 1895, and May, 1897 (Reader).

New South Wales—1902 (Maiden).

On *Acacia* sp.

Queensland—Islands of Torres Straits, June, 1897 (Bailey^{18, 19}).

Portion of the original material named in Cooke's handwriting is in the National Herbarium, and our description is based upon that. In the original description by Cooke and Massee the uredospores were unfortunately mistaken for teleutospores and *vice versa*. The uredospores are easily known from being obtusely warted and with equatorial germ-pores, apart altogether from size and shape.

The teleutospore is solitary at the apex of the pedicel, but the septum at a short distance from the spore foreshadows the *Uromycladium* with a colourless vesicle or cyst produced laterally immediately beneath septum.

The nature of the teleutospore and the presence of a septum in the stalk was so suggestive of *Uromycladium* that the material was specially examined to see if more than one spore was borne on a stalk, but the most careful search failed to reveal any indications that this was the case.

(Plate XIX., Figs. 158-160.)

Hardenbergia.

16. *Uromyces hardenbergiae* McAlp.

Sori on under surface of leaf, brown, crowded, globose to ellipsoid, often confluent, bullate, with ruptured epidermis, which usually remains in large patches.

II. Uredospores golden-brown, elliptic to ovoid, echinulate, relatively thick-walled, with three distinct equatorial germ-pores on one face, $25-35 \times 20-22 \mu$, average $27 \times 20 \mu$.

III. Teleutospores intermixed with uredospores, very sparse, ruddy-brown, thick-walled, smooth, ellipsoid to obovoid, slightly thickened at apex, with hyaline apiculus and showing germ-pore, $25-28 \times 18-21 \mu$, average $26 \times 19 \mu$; pedicel persistent, hyaline, elongated, up to 35μ long.

On leaves of *Hardenbergia monophylla* Benth.

Victoria—Kergunyah, Dec., 1903, II., III. (Robinson). Frankston, January and August, 1904, II. (Robinson).

The teleutospores were exceedingly rare, and somewhat resembled the uredospores, but slightly smaller, with ruddy smooth epispore and hyaline apiculus.

This species persists all the year round.

Darlucal filum Cast., very prevalent on uredosori.

(Plate XVII., Figs. 143-145; Plate G., Fig. 34.)

Acacia.

17. ***Uromyces phyllodiorum*** (B. and Br.) McAlp.

Berkeley and Broome, Linn. Trans. II., p. 67 (1883).

Cooke, Handb. Austr. Fung., p. 331 (1892).

Sacc. Syll. VII., p. 556 (1888).

Melampsora phyllodiorum Berkeley and Broome, Linn. Trans., II., p. 67 (1883).

Uromyces digitatus Winter, Rev. Myc., p. 209 (1886).

Uromyces phyllodiae Cooke and Mass. Grev. XVII., p. 70 (1889).

O. Spermogonia brown at first, becoming shining black, numerous, small, blister like, seated in centre of swollen, brownish, scattered, discoid, amphigenous tubercles, varying in size from 1 to 4 mm.

II., III. Sori surrounding spermogonia or alone, ruddy brown to dark-brown, round or elongated, crowded, often confluent, compact, raised, girt by the ruptured epidermis, which bursts irregularly.

II. Uredospores golden yellow to golden brown, oval to ellipsoid, rounded at apex or bluntly pointed and slightly thickened, densely warted, and warts arranged in regular longitudinal lines, with distinct equatorial germ pores, 3-4 on one face, and even reaching to 6, $35-54 \times 16-25 \mu$, average $38 \times 22 \mu$, with elongated and hyaline pedicel.

III. Teleutospores at first intermixed with uredospores, lemon yellow, and sometimes almost colorless towards base, fusiform to wedge-shaped, thickened at apex, and bearing finger-like erect or divaricate processes, sometimes a single process, or bifid, or several, $60-70 \times 14-20 \mu$, but may even reach a length of 86μ ; pedicels long, persistent, hyaline; paraphyses intermixed with teleutospores or with uredospores accompanied by teleutospores, elongated, variously shaped, but generally somewhat cylindrical, thickened and rounded at apex, and tapering sometimes into a slender filament at base, $70-93 \times 6-10 \mu$.

On phyllodes of *Acacia notabilis* F.v.M.

S. Australia—Near Gawler, July, 1885 (Tepper) (Ludwig²).

On phyllodes of *Acacia dallachiana* F.v.M., and *A. penninervis* Sieber.

Victoria—Alps, near Bright, Dec., 1904 (C. French, jun.)

On phyllodes of *Acacia dealbata* Link.

Victoria—Orbost, Dec., 1905, II. III.

On phyllodes of *Acacia penninervis* Sieber, *A. microbotrya* Benth. and *A. nerifolia* A. Cunn. in National Herbarium, Melbourne.

New South Wales—Twofold Bay.

Queensland—Brisbane River.

On phyllodes of *Acacia pruinosa* A. Cunn.

New South Wales—Gosford, Jan., 1906 (Froggatt).

On *Acacia* sp.

Queensland—Brookfield, Brisbane River (Bailey^{1, 19}).

New South Wales—(Cobb¹⁰).

The appearance presented by this rust varies according to the presence or absence of spermogonia. In the Queensland specimens there are black discoid tubercles with spermogonia in the centre and surrounded by the sori, while in the Alpine specimens the numerous sori are scattered over the green surface of the phyllode.

The size of the uredospores is given by Winter as $32-35 \times 20-25 \mu$, but there are occasional elongated forms which may reach a length of 54μ . They somewhat resemble those of *Uromycladium notabile*, but the markings on the epispore are much closer together.

The teleutospores are very characteristic, but very variable both in shape and size. The apex may be prolonged into a single process, or there may be quite a number, at least up to 6. As regards size they are generally elongated, and the measurements given are the mean of a number taken from spores ending in a single process. They germinate at once without a period of rest. The specific name of *digitatus* is so appropriate that it is unfortunate it has to be set aside in obedience to the law of priority.

This species was first described by Berkeley and Broome in a list of fungi from Brisbane, Queensland, as *Melampsora phyllodiorum* in 1883, and drawings accompany the description. Specimens of the original material have been kindly supplied to me by Mr. F. M. Bailey, Queensland State Botanist, and uredospores and teleutospores from these are shown in Pl. XXV., Figs. 218-220. There is no doubt as to its identity.

The following is the original description of Berkeley and Broome:—"Sori in amphigenous tubercles; spores arising from delicate filaments, rather fusiform, $55-58 \mu$ long, granulated, mixed with others which are elongated, uniseptate, fusiform, even, 22μ long." The longest uredospore I found was 54μ long, and the uniseptate spores of *Darluca filum* Cast., were also very common.

Next, Winter, in 1886, described the same fungus from S. Australia as *Uromyces digitatus*, the teleutospores being recorded for the first time.

Then Cooke and Massee, in 1889, described a *Uromyces phyllodiae* from Brisbane as follows:—"Sori minute, orbicular, compact, brown, crowded on elliptic, bullate, brown spots, $3-5 \text{ mm.}$ long, at length naked, not pulverulent. Uredospores not seen. Teleutospores elliptic, obtuse, rarely apiculate, brown; epispore minutely warted, rather thick, hyaline, thickened at the apex, $40-45 \times 16-18 \mu$." A portion of the original material was supplied by Mr. Bailey, and both uredospores and teleutospores have been found.

Cooke and Massee mistook the uredospores for teleutospores, but the existence of several germ-pores, together with their general appearance, indicate their true nature. Spermatogonia were present in this material.

Finally Dr. Cobb,¹⁰ in 1897, described the uredo stage of *Melampsora phyllodiorum*, and gives a drawing of the uredospores with an average size of $41 \times 17 \mu$. He also found the perithecia of *Darluka filum* Cast., among the sori, but their true nature was not recognised.

(Plate XXV., Figs. 218-228.)

Trifolium.

18. *Uromyces trifolii* (Alb. and Schw.) Winter.

Winter, Die Pilze, I., p. 159 (1884).

Cooke, Handb. Austr. Fung., p. 330 (1892).

Sacc. Syll. VII., p. 534 (1888).

O. Spermatogonia honey-coloured, disposed in small clusters.

Spermatia hyaline, globose, about 3μ diam.

I. Aecidia in circular clusters, on pallid spots; pseudoperidia cup-shaped, with a white lacinate margin.

Aecidiospores subglobose, ellipsoid or irregular, very finely verrucose, pale orange, $14-23 \mu$ diam., or $22-25 \times 14-16 \mu$.

II. Uredosori rounded or elliptic, scattered, surrounded by the torn epidermis, ruddy brown.

Uredospores irregularly globose or shortly elliptic, echinulate, golden-brown, with two equatorial germ-pores on one face, $22-26 \times 18-20 \mu$.

III. Teleutosori smaller and rounded on the leaves, larger and elongated on the petioles, dark brown, almost black, bullate, long covered by the leaden epidermis.

Teleutospores generally intermixed with uredospores, ellipsoid, globose or pear-shaped, thickened at the apex with a small pale wart, smooth, dark-brown, $22-30 \times 19-22 \mu$, average $24 \times 20 \mu$; pedicels long, hyaline, deciduous.

On leaves, petioles and stems of *Trifolium repens* L.

Victoria—Near Melbourne, Apr., I., II., III. Sep., I., III. Bunyip, Nov., I., II. Nyora, Apr., I., II., III. Murramurrangbong Ranges, Jan., I., II., III.

New South Wales—(Cobb¹²).

Tasmania—(Rodway¹).

All the stages were found together in January and April, and occurred on petiole, leaf, and stalk of inflorescence. The uredospores and teleutospores were very common, but the aecidiospores were not so common, and they were found also on the calyces. The leaf stalk was often much swollen and distorted. The spermatogonia usually precede the aecidia. The teleutospores are considered to germinate only after a period of rest, but they were observed in April, to germinate freely while on the leaf.

The mycelium may be perennial, and Dietel² considers this a common occurrence.

(Plate XVII., Fig. 142; Plate G., Fig. 32.)

POLYGONACEAE.

*Muehlenbeckia.*19. *Uromyces politus* (Berk.) McAlp.

Berkeley, Linn. Journ. XIII., p. 174 (1872).
 Berkeley and Broome, Linn. Trans. II., p. 67 (1883).
 Cooke, Handb. Austr. Fung., p. 342 (1892).
 Sacc. Syll. VII., p. 833 (1888).

Roestelia polita Berk.

- I. Aecidia on dark- purplish, elongated patches, generally arranged in lines which may be parallel, bursting through epidermis, bright orange, becoming ivory-coloured with age, cylindrical to slightly compressed, straight, averaging $1\frac{1}{2}$ mm. high; pseudoperidia polished, smooth, with white, narrow, toothed margin; peridial cells oblong to angular, with striated margin, $32-35\ \mu$ long.

Aecidiospores ochraceous, variable in size and shape, generally ellipsoid to ovoid or oblong, finely echinulate, $24-30 \times 19-22\ \mu$.

- III. Teleutosori on the same discoloured area as the aecidia and associated with or distinct from them, solitary or confluent, brownish to blackish, bullate, elongated to oval, surrounded by the raised and ruptured epidermis, compact, 1-2 mm. long.

Teleutospores yellowish-brown, smooth, ellipsoid to oblong, rounded or pointed and apiculate at apex, thickened ($6-8\ \mu$), occasionally two-celled, variable in size, $28-40 \times 20-25\ \mu$, average $32 \times 24\ \mu$; pedicel hyaline, persistent, elongated up to $150\ \mu$.

On stems and branches of *Muehlenbeckia cunninghami*, F.v.M.

New South Wales—Pamamero Lake, Nov., 1860 (Berkeley²).

Victoria—Murray River, Koondrook, Nov., 1905 (C. French, jr.)

This species differs from *U. polygoni* in the projecting Roestelia-like aecidia, and in the larger teleutospores with elongated pedicels. Several two-celled teleutospores occurred, oblong, constricted at septum, upper cell with apiculate apex, thickened, and more deeply coloured than lower, which is sometimes colourless, size that of the largest ordinary teleutospores. The somewhat elongated aecidia, in the absence of any other stage, led Berkeley to regard this as a species of *Roestelia*, but the finding of specimens by Mr. C. French, jr., with teleutospores in addition, showed it to be one of the *Uromyces*.

Berkeley² first recorded the aecidial stage of this species on *Muehlenbeckia cunninghami* in the Journal of the Linnean Society XIII., 174 (1872), and at the same time *Cronartium asclepiadeum* was noted on *Jacksonia scoparia* from the Darling Downs, Queensland.

Then just ten years later, in the transactions of the same society for 1882, p. 67, *R. polita* is recorded on the latter plant from Brisbane (Berkeley and Broome²), and it was rather peculiar, to say the least of it, that the same species of *Roestelia*, or even a *Roestelia* at all, should occur on plants so widely separated in a botanical sense as *Muehlenbeckia* (Polygonaceae) and *Jacksonia* (Leguminosae). At the end of his description Berkeley remarks "The plant is identical with a specimen in the Kew Herbarium, and is growing on the same plant, *Jacksonia scoparia* R. Br."

However, on examining the specimens on which this determination was based, it became evident how the error had arisen. Fortunately I have the specimen of *Jacksonia scoparia* from the National Herbarium, Melbourne, on

which *Cronartium* was first determined, and Mr. Bailey has sent me a specimen from his herbarium labelled "*Roestelia polita* Berk.," and which was so named by Berkeley. On comparing the Brisbane specimen with the Darling Downs specimen, they are seen to be the same, and Berkeley's original determination of *Cronartium* is correct. When it is remembered that *Roestelia polita* Berk., has only been found on *Muehlenbeckia* and not on *Jacksonia* it will reconcile certain discrepancies in Berkeley's original descriptions and drawings. In the original description of *R. polita* the spores are given as large, while in connexion with its occurrence on *Jacksonia* it is stated—"the spores are globose about .0003 inch in diam. ($7-7\frac{1}{2}\mu$)." If we turn to the drawings on Pl. 15, the otherwise puzzling figures become clear when they are taken to represent a *Cronartium*, and it will be seen from the description of this fungus on *Jacksonia* that the so-called aecidiospores are really the promycelial spores of that fungus.

If the identical specimen in the Kew Herbarium, to which Berkeley referred, is examined I have no doubt it will turn out to be a *Cronartium*. At the time Berkeley wrote our knowledge of the distinctions between these forms was not so clear as now, but still the projecting pseudoperidium of the so-called *Roestelia*, with its characteristic peridial cells and contained spores, is quite distinct microscopically from the outwardly similar column of teleutospores of *Cronartium* which are wedged together into a solid mass.

In the original description the locality for New South Wales is given as "Bambamero" Lake, but Dr. Howitt informs me that the name is as above, and that the lake is situated 20 miles from Menindie, close to the Darling River.

(Plate XXXIX., Figs. 297, 298; Plate XLIII., Fig. 317.)

Polygonum.

20. *Uromyces polygoni* (Pers.) Fekl.

Fuckel, Symb. Myc., p. 64 (1869).

McAlpine, Agr. Gaz., N.S.W., VII., p. 301 (1896).

Sacc. Syll. VII., p. 533 (1888).

O. *Spermogonia* yellow to honey-coloured, conoid, in small groups.
Spermatia hyaline, minute, $3 \times 2\mu$.

I. *Aecidia* crowded in roundish patches, bright orange, mostly hypophyllous, but often opposite; pseudoperidia rather flat, with broad whitish torn edges.

Aecidiospores subglobose, finely verrucose, pale yellow to orange yellow, $16-28\mu$ diam.

II. *Uredosori* pale cinnamon to rusty brown, scattered, or arranged in a circinate manner and confluent, mostly amphigenous, pulverulent, round to oval, surrounded or partially covered by ruptured epidermis.

Uredospores ellipsoid to obovate, yellowish brown, finely echinulate, with generally two lateral germ-pores on one face, $20-29 \times 16-21\mu$, average $24 \times 20\mu$.

III. *Teleutosori* scattered, blackish, pulvinate, roundish on leaves, elongated on stems, bursting through browned epidermis, confluent in masses, surrounding and distorting stem.

Teleutospores globose, subglobose or elliptical, smooth, bright chestnut brown, apex thickened ($8\ \mu$), rounded or occasionally somewhat pointed, $22-34 \times 16-20\ \mu$, average $28 \times 18\ \mu$; pedicels pale yellowish, persistent, firm, long, up to $90\ \mu$.

On leaves and stems of *Polygonum aviculare* L.

Victoria—Near Melbourne, Rutherglen, Myrniong, Goornong, Ardmona, Bunyip, Murramurrangbong Ranges, &c. Common generally throughout the year.

Tasmania—Sandy Bay, January, 1906, II., III. (Rodway).

It is only recorded for Victoria and Tasmania, but is probably to be found wherever the host plant occurs. Aecidia were first found on young plants along with the other stages in November, 1904.

The uredospores are plentiful, more particularly in the spring and summer months, but the teleutospores are formed in the autumn months.

Darluca filum Cast., commonly occurring on uredosori, was found on teleutosori in May, 1904.

(Plate XVIII., Figs. 150, 151.)

CHENOPODIACEAE.

Atriplex.

21. *Uromyces atriplicis* McAlp.

Sori epiphyllous, orbicular, scattered, bullate, compact, ruddy brown, erumpent, girt by the ruptured epidermis, about $\frac{1}{2}$ mm. diam.

II Uredospores pale-brown, ellipsoid, finely echinulate, with 3-5 scattered germ-pores on one face, $25-29 \times 22\ \mu$.

III. Teleutospores intermixed with uredospores, dark brown, sub-globose to shortly ellipsoid, finely striated longitudinally, slightly thickened at apex, with prominent single apical germ-pore, $22-29 \times 24-27\ \mu$, average $26 \times 25\ \mu$.

On leaves of *Atriplex semibaccata* R. Br.

Victoria—Royal Park, near Melbourne, April, 1899. (Brittlebank).

The groups of spores shown in the Figures are rather smaller than the average, being about $22 \times 25\ \mu$. Occasionally an abnormal teleutospore occurred reaching a length of $37\ \mu$.

(Plate XVII., Figs. 146, 147.)

Beta.

22. *Uromyces betae* (Pers.) Kuehn.

Kuehn, Bot. Zeit., p. 540 (1869).

Cooke, Grev. XI., p. 98 (1883).

Cooke, Handb. Austr. Fung., p. 330 (1892).

Sacc. Syll. VII., p. 536 (1888).

O. Spermatogonia yellowish to honey-coloured, in small clusters, on both surfaces of leaf.

Spermatia hyaline, ellipsoid, $5-6 \times 3\ \mu$.

I. Aecidia disposed on orbicular or oblong yellow spots, on both surfaces of leaf, mostly about mid-rib and on leaf stalk; pseudo-peridia white, cup-shaped, with reflexed fringed margin; peridial

cells firmly united, thickened all round but thicker on one side, striated, individually somewhat lozenge-shaped, collectively elongated polygonal.

Acidiospores angular, globose or oblong, orange-yellow, smooth, $18-28 \times 16-22 \mu$.

- II. Uredosori cinnamon or chestnut-brown, scattered or circinate, small, surrounded by the ruptured epidermis.

Uredospores sub-globose, elliptic or ovoid, yellowish-brown, echinulate, with two distinct equatorial germ-pores on one face, $25-32 \times 16-25 \mu$, average $28 \times 21 \mu$.

- III. Teleutosori dark-brown, margined by the ruptured cuticle, scattered or orbicularly arranged.

Teleutospores ovate or ellipsoid with a colourless papilla at apex, dark-brown, smooth, $26-35 \times 19-25 \mu$, average $32 \times 21 \mu$; pedicels thin, rather long, soon deciduous.

On leaves of *Beta vulgaris* L.—Beet and Mangel.

Victoria—This rust generally occurs wherever beet or mangels are cultivated, and has been found at Port Fairy, Maffra, Murtoa, Minyip, Ballarat, etc. It also occurs throughout the year from Jan. and Feb. to Nov. and Dec. As early as 1878 this rust from Ballarat was determined by Thuemen².

S. Australia—Aug., 1897 (Quinn).

Tasmania—(Rodway¹). Devenport, Jan., 1906 (Robinson).

New South Wales—Hawkesbury Agric. College (Musson).

The teleutospores are rather scarce, but they were found at Port Fairy in August and measured $27-33 \times 22-24 \mu$.

The acidiospores were found towards the latter end of August and up to December on young leaves of beet growing from roots left in the ground during the winter. According to Plowright they very rarely occur in Britain in a state of nature. They were found to germinate very freely in water.

(Plate XVII., Figs. 148, 149; Plate XLIII., Fig. 316; Plate H.)

SAPINDACEAE.

Diploglottis.

23. *Uromyces diploglottidis* Cooke and Mass.

Cooke and Masee, Grev. XVII., p. 55 (1889).


Cooke, Handb. Austr. Fung., p. 331 (1892).

Sacc. Syll. IX., p. 294 (1891).

- III. Sori epiphyllous, scattered, convex, minute, for a long time covered, at length splitting, pale brown, seated on orbicular greenish spots.

Teleutospores elliptic, apex obtusely acuminate, base attenuated into a short pedicel, epispore hyaline, thick, contents granular, pallid, $50-60 \times 20-30 \mu$.

On fading leaves of *Diploglottis cunninghamii* Hook. f.

 Queensland—Woolston Scrub, Brisbane River (Bailey^{6, 19}).

This species was very destructive to the foliage of the Queensland Tamarind Tree.

Specimen kindly sent by Mr. Bailey, but spores not obtainable.

CARYOPHYLLACEAE.

*Dianthus.*24. *Uromyces caryophyllinus* (Schrank) Schroet.

Schroeter, Brand. p. 10 (1869).

McAlpine, Agr. Gaz. N.S.W. VII., p. 300 (1896).

Sacc. Syll. VII., p. 545 (1888).

- II. Uredosori amphigenous, dark brown when exposed, but long covered by epidermis, round or oblong, scattered, often confluent, up to 3 mm. long.

Uredospores roundish to oblong, yellowish brown to golden brown, decidedly echinulate, generally 3-4 scattered or nearly equatorial germ-pores on one face, $21-34 \times 17-28 \mu$, average $32 \times 24 \mu$.

- III. Teleutosori amphigenous, blackish-brown, oblong, confluent in elongated lines, long covered by ashy epidermis, then margined by the ruptured and ragged cuticle.

Teleutospores at first intermixed with uredospores, roundish, oval or ovate, cinnamon brown, generally thickened, with broad colourless papilla, average $28 \times 20 \mu$ or $22-32 \times 17-23 \mu$; pedicels very deciduous, hyaline, up to 45μ long.

On stems and both surfaces of leaves of *Dianthus caryophyllus* L. and *D. chinensis* L.—Carnation and Dianthus.

Victoria—Near Melbourne, and at Ardmona. Very common in some seasons all the year round.

New South Wales—Ashfield, near Sydney. (Maiden.)

South Australia—Feb., 1902.

Queensland—Roma, 1901 (Tryon^s).

There is not much difference between the naked-eye characters of the uredo and teleuto sori, only the latter are a little darker in colour, but the spores themselves are quite distinct, for the uredospores are covered with decided spines, while the teleutospores are relatively smooth and have a clear papilla at apex.

The teleutospore is filled with finely granular protoplasm, in the centre of which is a large vacuole-like body. When the spore is examined in the dry condition, the surface appears to be covered with numerous very fine points, which Fischer^s regards as warts. The wall of the uredospore is beset with loosely arranged spines, which project at the margin when seen in optical section, while that of the teleutospore has densely crowded fine points, which are not visible at the margin. These projecting points are so fine that the spore is generally described as smooth.

Darlua filum Cast. is often parasitic on the uredosori and teleutosori.

(Plate XVIII., Figs. 152-154; Plate G., Figs. 30, 31.)

*Scleranthus.*25. *Uromyces scleranthi* Rostr.

Rostrup, Bot. Tidsskr., p. 40 (1897).

Sacc. Syll. XIV., p. 275 (1899).

- II. Uredosori scattered, minute, orbicular or oblong, slightly raised, pale brown, erumpent, and surrounded by the ruptured epidermis.

Uredospores golden brown, finely echinulate, ellipsoid to ovoid or oblong, 3-4 scattered germ-pores on one face, epispore 3 μ thick, 25-32 \times 17-21 μ .

On *Scleranthus diander* R. Br.

Victoria—June, 1898 (Reader).

Only the uredo-stage was found although numerous sori were examined and while the uredospores generally agree with those of the above species they are sometimes a little longer.

It was originally found in Denmark on the stems and calyces as well as the leaves of *Scleranthus perennis* L.

The description is as follows :—"Sori scattered, minute, orbicular or oblong, pale brown, long covered by epidermis. Uredospores yellowish-brown, globose, echinulate, 15-22 μ diam. or oblong, 24-25 \times 18-20 μ .

Teleutospores rare, intermixed with uredospores, pear-shaped or obliquely ellipsoid, reddish-brown, apical papilla transversely thickened, 23-24 \times 19-24 μ ; pedicel hyaline, deciduous."

(Plate XXVIII., Fig. 248.)

ZYGOPHYLLACEAE.

Zygophyllum.

26. *Uromyces vesiculosus* Wint.

Winter, Hedw. p. 22 (1885).

Cooke, Handb. Austr. Fung., p. 330 (1892).

Sacc. Syll. VII., p. 547 (1888).

Sori amphigenous, scattered or gregarious, often confluent, rounded or irregular, ruddy brown, covered by the cinereous vesicular epidermis, which ultimately ruptures and surrounds the sorus.

II. Uredospores sub-globose, elliptic or ovate, yellow to brownish, densely warted, even prickly, epispore thin, with 3-5 equatorial germ-pores on one face, 26-35 \times 19-24 μ , average 28 \times 20 μ .

III. Teleutospores globose, elliptic, ovate or pear-shaped, thickened at the apex, rounded or with a broad apiculus more or less shortly conical, 21 μ diam., or 23-31 \times 17-22 μ , average 25 \times 20 μ ; epispore thick, smooth, dark bay brown when mature ; pedicel long, thick, persistent, may be flexuous, pale olivaceous, up to 150 μ .

On living leaves and stems of *Zygophyllum billardieri* DC.

S. Australia—Spencer's Gulf (Tepper). (Winter¹).

On leaves, stems, and fruit capsules of *Z. glaucescens* F.v.M.

Victoria—Near Dimboola, November, 1894, and Warracknabeal, March, 1904 (Reader).

S. Australia—Yorke's Peninsula, June, 1902 (Molineux).

The confluent sori may form large conspicuous elongated patches up to 10 mm. long or more, and the greyish bladder-like epidermis remains unbroken for some time. Several two-celled teleutospores were met with and not constricted at the septum, which was decidedly thick and rather below the middle, sometimes approaching the base. They were, in other respects similar to the ordinary teleutospores, even to the size, and measured about 27 \times 22 μ .

Dietel observes that the occurrence of bicellular teleutospores is rare among *Uromyces*, for only once has he observed it in *U. pisi* and *U. junci*, and two were found in *U. limosellae*. Dr. Cooke has also found a few in *U. trifolii*, and I have now to add *U. orchidearum*, *U. tricorynes*, *U. vesiculosus* and *U. politus*.

Darluka filum Cast., is generally very plentiful on uredosori.

(Plate XVIII., Fig. 155-157 ; Plate G., Fig. 33.)

UROMYCLADIUM McAlp.

This new genus of Rusts is noteworthy, not only on account of the teleutospores forming a cluster at the top of the stalk, and generally accompanied by a colorless cyst, but from the large galls produced by some species which seriously disfigure and ultimately destroy many of our Wattle-trees (*Acacias*).

The seven species at present known show every gradation from one teleutospore accompanied by a cyst (*U. simplex*) through two teleutospores with or without a cyst (*U. maritimum*), (*U. bisporum*), and reaching to three teleutospores in a head always without a cyst (*U. tepperianum*). The presence of more than one teleutospore at the end of a stalk is a novel feature in rusts, and the addition of a colorless vesicle or cyst at the base reminds one of *Ravenelia* to which this genus is allied. The unicellular teleutospore also links it on to *Uromyces*, and I consider that here we have the connecting link between *Uromyces* on the one hand and *Ravenelia* on the other. The genus *Anthomyces* with only a single species is composed of a head of three or more cells united together with sterile cells at the base, and may prove a bridging species from *Uromycladium* to *Ravenelia*. Spermatogonia, uredosori and teleutosori occur, but no aecidia. The two gall-producing species hitherto found are *U. notabile* and *U. tepperianum*, both of which produce three teleutospores at the top of the stalk, and the former has uredosores in addition. The only species known outside of Australia is that of *U. tepperianum* (formerly called *Uromyces tepperianus*, Sacc.), and it is noted for causing deformation of the shoots, but with us it is ruining whole plantations of Wattles. Near Altona Bay, Victoria, the branches of the beautiful Golden Wattle (*Acacia pycnantha*) are deformed and destroyed by it when it forms numerous galls sometimes as large as a potato. In the neighbourhood of Melbourne, too, hedges of the Kangaroo thorn (*A. armata*) are being gradually and completely destroyed by this fungus. Some of the shrubs have most of their branches infested with the chocolate colored galls, the color being due to the spores, and they may be in the form of a succession of small ones as large as peas, or large ones the size of walnuts. The phyllodes as well as the branches in some species are deformed. On cutting across these galls they are seen to be solid to the core, and not the product of insects but of the fungus, although in many cases bored and tunnelled by insects after being produced. When our *Acacias* are more closely examined for rusts no doubt the number of species will be considerably increased.

General characters—Spermatogonia somewhat hemispherical, produced under the cuticle, without paraphyses at mouth, preceding the formation of any other spore.

Uredosores solitary at apex of basidia, and generally much larger than teleutospores with several distinct germ-pores.

Teleutospores in clusters, composed of one spore and cyst or two or more spores with or without a cyst, depressed globose.

This genus may be distinguished from *Uromyces* by the arrangement of the teleutospores, by their shape, which is not elliptical, but depressed globose, and by the presence, in most cases, of a colorless vesicle or cyst.

Allied with *Uromyces* on the one hand and *Ravenelia* on the other.
Australian species, 7.

ANALYTICAL KEY TO THE SPECIES.

I. One teleutospore and vesicle in head.

A. Uredospores fusiform, with hyaline apiculus, and finely warted.

Ur. simplex.

B. Uredospores sub-elliptical, without hyaline apiculus, thickened at apex, and coarsely warted.

Ur. robinsoni.

II. Two teleutospores in head.

A. Uredospores unknown.

Ur. bisporum.

III. Two teleutospores and vesicle in head.

A. Uredospores sub-elliptical, warted all over, much thickened and dentate at apex.

Ur. maritimum.

B. Uredospores sub-clavate, evenly warted all over, and scarcely thickened at apex.

Ur. alpinum.

IV. Three teleutospores in head.

A. Teleutospores finely warted, warts arranged in lines ; uredospores known.

Ur. notabile.

B. Teleutospores with converging striae ; uredospores unknown.

Ur. tepperianum.

LEGUMINOSAE.

Acacia.

27. *Uromycladium alpinum* McAlp.

O. Spermatogonia minute, black, shining, punctiform, crowded, on both surfaces of phyllodes on discoloured patches, appearing before sori and ultimately surrounded or accompanied by them.

Spermatia hyaline, ellipsoid, $3 \times 2 \mu$.

Sori amphigenous, rusty-brown, scattered or in groups, bullate, soon rupturing epidermis and becoming naked.

II. Uredospores yellowish-brown to golden-brown, shortly or elongated clavate, occasionally oval or oblong, warted equally all over, scarcely thickened at apex, with 3-5 equatorial germ-pores on one face, $35-51 \times 21-26 \mu$, occasionally reaching a length of 58μ .

III. Teleutospores at first intermixed with uredospores, two in head with colorless vesicle, depressed globose to subglobose, yellowish-brown to dark-brown, smooth, very slightly thickened at apex with distinct germ-pore, $19-22 \times 25-30 \mu$; vesicle arising from stalk immediately beneath septum, globose or slightly ellipsoid about 25μ diam.

- X. Mesospores associated with uredospores, not uncommon, ellipsoid to oblong or obovate, rounded at apex, smooth-walled and wall of about equal thickness throughout, with colorless stalk, $15-25 \times 10-15 \mu$. They differ from uredospores in being smooth and much smaller, and from the teleutospore in shape, in not being thickened at apex and without apical germ-pore.

On phyllodes of *Acacia dallachiana* F.v.M.

Victoria—Alps, near Bright, Dec., 1904 (C French, jr.).

On phyllodes of *Acacia busifolia* A. Cunn.

New South Wales—New England. (From type of host in National Herbarium, Melbourne.)

On leaves and pods of *A. dealbata* Link.

Victoria—Murrumbidgee Ranges, Jan., 1905 (Robinson).

Tasmania—Risdon, Dec., 1905, and Mt. Wellington, Jan., 1906 (Rodway).

On phyllodes of *A. implexa* Benth.

Victoria—Myrniong, May, 1905 (Brittlebank).

On phyllodes and pods of *Acacia linifolia* Willd., in National Herbarium, Melbourne.

New South Wales—Blue Mts.

Queensland—Rockhampton, Nerbool Creek.

This species very much resembles *U. simplex* in the appearance of the sori, but it is allied to *U. maritimum* in bearing two teleutospores and a vesicle on one sporophore. It differs from the latter, however, in the uredospores which are generally clavate and warted equally all over.

The vesicles vary in size, and are sometimes large and swollen when they are ready to burst. In old material they may have disappeared altogether. The teleutospores were much more numerous than the uredospores in December.

(Plate XXIV., Figs. 209-215.)

Acacia.

28. *Uromycladium bisporum* McAlp.

- III. Teleutosori on the branchlets forming elongated slightly swollen chocolate brown masses, and on the under surface of the leaflets appearing as powdery patches.

Teleutospores two in a head, yellowish-brown, subglobose to depressed globose, occasionally with very short, colored, stalk-like, basal projection, slightly thickened at apex with germ-pore immediately beneath, $18-22 \times 22-30 \mu$.

On branches, leaves and pods of *Acacia dealbata* Link.

Victoria—Murrumbidgee Ranges, January, 1905 (Robinson).

Tasmania—Risdon, Dec., 1905 (Rodway).

No vesicle occurs below the septum, so that this species is an intermediate form between *U. simplex* with a single spore and vesicle and *U. maritimum* with two spores and a vesicle in each head. The occasional presence of two teleutospores in *U. simplex* is a further indication of the passage from one to the other.

(Plate XXIV., Figs. 207, 208 ; Plate XXXIII.)

29. *Uromycladium maritimum* McAlp.

O. Spermogonia at first ruddy-brown, ultimately black, dotted over the surface of prominent discoid tubercles, formed at corresponding points on both surfaces of the phyllodes, somewhat hemispherical, but broader than deep, and produced beneath the cuticle, averaging $120\ \mu$ diam.

Spermatia hyaline, shortly ellipsoid, $3 \times 2\ \mu$.

II., III. Sori dark-brown, elongated, compact, confluent, rupturing epidermis, 2–3 mm. long, partially surrounding the black discoid spermogonial tubercles.

II. Uredospores oval to elliptical or elongated elliptical, pale-brown to dark-brown, warted all over and thickened at apex, where spikes are specially prominent, forming a tuft, with very distinct equatorial pores, 3–7 on one face, very variable in length and breadth, $45\text{--}60 \times 24\text{--}28\ \mu$; pedicel deciduous, hyaline, elongated, up to $106 \times 5\ \mu$.

III. Teleutospores at first intermixed with uredospores, two on each sporophore, with a lower and lateral colorless vesicle, very rarely three spores in cluster without a vesicle, subglobose to depressed globose, dark-brown, thick walled, smooth, with finely granular contents, slightly thicker at apex, with very prominent apical germ-pore, $30\text{--}32\ \mu$ diam., or $22\text{--}25 \times 24\text{--}30\ \mu$; colorless vesicle globose, with very thin wall, and arising from stalk immediately beneath septum, $30\text{--}35\ \mu$ diam.

X. Mesospores intermixed with the uredospores, or even with uredospores and teleutospores, unicellular or very rarely bicellular, pale, smooth, with wall of equal thickness and finely granular contents, without any visible germ-pores, fusiform or ellipsoid, or even occasionally clavate, solitary at the end of a stalk like the uredospores, $22\text{--}45 \times 11\text{--}19\ \mu$, occasionally up to $57\ \mu$ long.

On phyllodes and stems of *Acacia longifolia* Willd.

Victoria—Sandringham and Beaumaris.

Tasmania—Mersey Bluff, Jan., 1906 (Robinson).

II. April to August, occurring alone, or sparingly mixed with teleutospores. III. September to latter part of spring and during summer, intermixed with a few uredospores.

In one form or another it occurs all the year round.

This rust was first found on the coast at Beaumaris in 1895 on *Acacia longifolia*, although not investigated at the time, and it was in this species that the peculiar grouping of the teleutospores and the presence of a colourless vesicle or cyst was first observed.

The teleutospores germinate freely in water or moist air and without a period of rest. They germinate all round the sorus on the surface of the phyllodes, forming a flaky mass of spores and sporidiola, which easily peels off.

The uredospores were only found to germinate in water in the spring.

The spermogonia are associated with uredo and teleutospores occurring in the same sorus.

Only in rare instances were sori found without being accompanied by spermogonial tubercles.

(Plates XX., XXI., Figs. 166–184; XXIV., Figs. 216, 217; XXXII., Fig. 273; XLIII., Figs. 313, 314, 315.)

30. *Uromycladium notabile* (Ludw.) McAlp.

Ludwig, Bot. Centrbl. XLIII., p. 6 (1890).

Cooke, Handb. Austr. Fung., p. 343 (1892).

Sacc. Syll. XI., p. 222 (1895).

Uredo notabilis Ludw.

- O. *Spermogonia* minute, punctiform, black, in swollen tubercles often intermixed with uredospores and teleutospores.

Spermatia hyaline, ovate or ellipsoid, on elongated basidia, $4 \times 2-3 \mu$.

- II. Uredosori on both surfaces of phyllodes, on branches and pods, ochraceous to yellowish-brown, seated on a distorted inflated gall.

Uredospores ellipsoid to oblong, bright yellow when fresh, becoming yellowish-brown, on elongated hyaline pedicels, with 3-5 equatorial germ-pores on one face; epispore thick (3μ), reticulate, $30-45 \times 18-28 \mu$.

- III. Teleutosori on branches, phyllodes and legumes, forming large, swollen, distorted galls, chocolate-brown, at length very powdery.

Teleutospores intermixed with uredospores at first, in clusters of three (rarely two or four), sub-globose to depressed globose, yellowish-brown, densely covered with warts arranged in lines, slightly thickened at apex, with germ-pore beneath, $16-23 \times 21-26 \mu$.

On phyllodes of *Acacia notabilis* F. v. M.

South Australia—Roseworthy, Sept., 1889, II. (Tepper).

On branches, leaves and pods of *Acacia dealbata* Link.

Victoria—Murrumbidgee Ranges, Jan., 1905, O., II., III. (Robinson). Bright, June, 1905, II., III. (Davey). Bairnsdale and Orbost, Dec., 1905, III.

Tasmania—Hobart, May, 1905, II. (Rodway). Cataract Gorge and Dulverton, Jan., 1906, III. (Robinson).

On branches of *Acacia decurrens* Willd.

Victoria—Near Melbourne, Feb., 1905, III. Myrniong, July, 1905, III.

New South Wales—Exeter, near Moss Vale, May, 1905, III. (Baker).

On branches of *Acacia elata* A. Cunn.

New South Wales—Lawson on the Blue Mountains, April 1905, O., III. (Baker).

On branches of *A. binervata* DC.

New South Wales—Sydney, Sept., 1905, III. (Maiden.)

On branches of *Acacia pruinosa* A. Cunn.

New South Wales—Gosford, Jan., 1906, II. (Froggatt.)

The ochraceous uredosori are generally distinct from the chocolate-brown teleutosori, but sometimes the two kinds of spores are found intermixed.

The arrangement of the teleutospores is generally the same as in *U. tepperianum*, but the dense covering of warty spines instead of distinct striae differentiates them at once and the height of the spore is greater. The spermogonia are found in association with both uredospores and teleutospores.

The uredospores closely resemble in size and shape those of *Uromyces phyllodiorum*, but the surface markings serve to distinguish them. In the

latter the warts are arranged in longitudinal lines, while in the former the surface markings are net-like. See Plate XXIII., Figs. 201, 202, and Plate XXV., Fig. 226.

Some very large galls were found either surrounding or terminating branches of the Black Wattle (*A. decurrens*). A size of 3-4 inches in diam. was not uncommon, and one large clump resembling a big artichoke measured 5 x 14 inches, and weighed 15 ounces. In some cases the branches still flourished beyond the gall, but it was evidently an expiring effort of the tree to put forth leaves. The particular tree on which the largest galls occurred was about 30 feet high and 13 years old, but many of the branches were decaying, and it looked altogether rather dilapidated on account of the numerous galls which were often tunnelled by insects.

The mycelium was evidently perennial, as some of these galls were several years old.

Only the uredospores of this species were found at first, and were described as *Uredo notabilis* by Ludwig. Dietel² has thrown out the suggestion in his paper on "The Genus *Ravenelia*," that from the nature of the uredospores in Ludwig's species they may be found to belong to *Ravenelia*, and, considering the relationship of this genus with *Uromycladium*, the suggestion turns out to be not far from the truth.

(Plate XXIII., Figs. 196-205 ; Plate XXXVI.)

Acacia.

31. *Uromycladium robinsoni* McAlp.

- O. Spermogonia on discoid tubercles, minute, punctiform, ruddy-brown, partially or entirely surrounded by uredosori or teleutosori.

Spermatia hyaline, minute, sub-globose, about 3-4 μ diam.

- II., III. Sori amphigenous, numerous, crowded, up to $\frac{3}{4}$ mm. diam., light rust color, soon erumpent, powdery, and often surrounding spermogonial tubercles.

- II. Uredospores pale yellowish, oval to ellipsoid or elongated elliptical, thickened at apex (up to 6 μ), warted all over, particularly at apex, with 2-3 equatorial germ-pores on one face, 38-45 x 19-22 μ .

- III. Teleutospores at first intermixed with uredospores, solitary at end of sporophore, with lateral vesicle beneath, golden yellow to golden brown, depressed globose to sub-globose, smooth, slightly thickened at apex, 19-26 x 25-34 μ ; vesicle hyaline, globose to shortly ellipsoid, often on distinct stalk with septum at base, 20-25 μ diam. or 22-27 x 16-23 μ .

- X. Mesospores not uncommon, ellipsoid to elongated ellipsoid or elongated oblong, with thin and smooth walls, rounded at apex, without germ-pores, 18-22 x 9-12 μ .

On phyllodes of *Acacia melanoxylon* R. Br.

Victoria—Murrumbidgee Ranges, Nov. 1902, Dec. 1903, Jan. 1905 (Robinson). Myriong, May, 1905 (Brittlebank).

Tasmania—Hobart, Dec., 1905 (Rodway).

This species was found near Kergunyah by my assistant, Mr. G. H. Robinson, in whose honor it is named. The teleutospores give a dingy appearance to the phyllodes on both surfaces, and sometimes the sori are so crowded as to convey the impression of a continuous mass of rust, or even

red dust. It resembles *U. simplex* in having a single teleutospore at the apex of the sporophore, with a lateral vesicle immediately below, but it differs chiefly in the shape and size of the uredospores. The powdery masses of teleutospores soon spread over the leaf and germinate *in situ*, forming flakes which are easily detached.

The spermogonia are seated on tubercles along with uredo and teleutospores, but there may be powdery patches of both kinds of spores even on the same phyllode, without spermogonia or the associated tubercles (Plate XXXII., Fig. 274). This species represents one of the simplest forms of the genus, in which the sporophore bears a single teleutospore with a lateral colorless vesicle immediately beneath it.

(Plate XXII., Figs. 185-189 ; Plate XXXII., Fig. 274.)

Acacia.

32. *Uromycladium simplex* McAlp.

O. Spermogonia ruddy-brown, crowded, minute, punctiform, arranged in a circinate manner on both surfaces of phyllodes and very occasionally on young branches.

Spermatia hyaline, shortly ellipsoid, $4-5 \times 3-4 \mu$.

Sori amphigenous, ruddy brown to dark brown, numerous, sometimes arranged in groups, bullate, soon rupturing epidermis and becoming naked.

II. Uredospores yellowish brown to golden brown, fusiform or oval, with hyaline apiculus, finely warted, with as many as six equatorial germ-pores on one face, three being very common, $48-58 \times 21-25 \mu$.

III. Teleutospores at first intermixed with uredospores, solitary at end of sporophore and lateral vesicle immediately beneath, yellowish brown, depressed globose to sub-globose, smooth, slightly thickened at apex and germ-pore directly beneath, $22-25 \times 25-32 \mu$; sporophore fitting into a sort of socket on base of spore, hyaline, elongated, 80μ or longer; vesicle hyaline, globose $19-22 \mu$ diam.

On phyllodes and branches of *Acacia pycnantha* Benth.

Victoria—Grampians, Nov., 1900 (C. French, jun.), Dec., 1900 (Robinson). Little River, Nov., 1902 and Jan., 1905 (C. French, jun.), Feb., 1905. Werribee Gorge, Dec., 1902, and Nov., 1904. Malvern Gardens, near Melbourne, Sept., 1905.

Very occasionally the colorless vesicle is replaced by an ordinary spore, thus showing that the sporophore bears at its apex two spores, or a spore and its substitute.

The sori form numerous hemispherical pustules which may run together, and during the latter part of spring and early summer, while the teleutospores are being produced, the exuded spores are observed imbedded in gum, freely germinating and readily detachable in flakes.

The uredospores somewhat resemble those of *Uromyces fusisporus*, but in the latter there are only 3-4 germ-pores on one face.

The spermogonia were first found in September on a young tree about four years old, and they usually occurred on distinct ruddy spots produced by *Coniothyrium pycnanthae* McAlp. and other fungi.

Darlucia filum Cast. not uncommon on sori containing both uredo and teleutospores.

(Plate XIX., Figs. 161-165 ; Plate XXXII., Fig. 275.)

Acacia.

33. ***Uromycladium tepperianum* (Sacc.) McAlp.**

Saccardo, Hedw. XXVIII., p. 126 (1889).

Cooke, Handb. Austr. Fung., p. 331 (1892).

Sacc. Syll. IX., p. 291 (1891).

Uromyces tepperianus Sacc.

- O. Spermatogonia minute, ruddy at first, then black, brownish by transmitted light, depressed globose, $150\ \mu$ diam.

Spermatia hyaline, ellipsoid, $3-3\frac{1}{2} \times 2-2\frac{1}{2}\ \mu$.

- III. Teleutosori on the leaves or phyllodes forming swollen distorted gall-like masses along their whole length, and on the branches long and broadly effused, or large somewhat spherical galls coated with cinnamon to chocolate-brown powdery spores.

Teleutospores in clusters of three, sphaeroid to depressed globose, cinnamon brown, thickly channelled and striate, striae converging towards apex, slightly thickened in upper portion of wall, $14-17 \times 18-25\ \mu$; sporophore hyaline, elongated, soon deciduous.

On branches of *Acacia salicina* Lindl.; *A. hakeoides* A. Cunn.; *A. myrtifolia* Willd.; and *A. spinescens* Benth.

S. Australia—Blackhills, Sandy Creek, Murray Bridge, etc., Dec., 1889 and 1892 (Tepper). Dec., 1901 (Molineux).

On phyllodes and branches of *A. armata* R. Br.; *A. implexa* Benth.; *A. juniperina* Willd.; *A. melanoxyton* R. Br.; *A. pycnantha* Benth.; *A. rigens* A. Cunn.; *A. siculiformis* A. Cunn.; *A. vomeriformis* A. Cunn.

Victoria—Mallee near Hopetoun, Oct., 1903 (C. French, jun.). Ringwood, Aug., 1904, (C. French, jun.). Werribee Gorge, Jan., 1905, (Brittlebank). Oakleigh, Jan., 1905. Little River, Jan., 1905, (C. French, jun.), and Feb., 1905. Cheltenham, May, 1905, (Robinson). Myrniong, July, 1905. Mt. Macedon, 1882, and Murray River, 1874, from types of *A. siculiformis* and *A. vomeriformis* in National Herbarium, Melbourne. Common around Melbourne.

On *A. diffusa* Lindl.; *A. verniciflua* A. Cunn.; *A. verticillata* Willd.

Tasmania.—Hobart, March–April, 1905 (Rodway and Lea).

On *Acacia longifolia* Willd.

New South Wales—Rose Bay, near Sydney, July, 1905 (Froggatt).

On branches and phyllodes of *A. erioclada* Benth., and *A. glaucoptera* Benth.

West Australia—From types of host in National Herbarium, Melbourne.

On *Acacia stricta* Willd.

Tasmania—Gordon, D'Entrecasteaux Channel, Nov., 1905 (Rodway).

This species was first described and illustrated by Saccardo in 1889, who considered that the unicellular teleutospores were borne singly on long stalks, hence he placed it in the genus *Uromyces*. He failed to observe, however, that each sporophore bore a cluster of three in a head. It is the most widespread of all the known forms being found on nineteen different species of *Acacia*, and it shares the property with *U. notabile* of producing galls. This is particularly noticeable in the Golden Wattle (*A. pycnantha*), where the galls are as large as potatoes, and in some of the Wattle plantations where the trees are cultivated for their bark they hang in

large numbers from the branches like so many fruits, and the trees are either dying or dead. (See Frontispiece.)

The dark chocolate-brown spore-masses are quite powdery, and each spore has prominent ribs running from base to apex, so that it is easily known from being fluted. In fact, the appearance closely resembles the markings on the eggs of some butterflies, and no doubt the purpose is the same, to strengthen the membrane which is already relatively thick, and prevent the spore collapsing when dry conditions prevail. Occasionally a spore has been found germinating *in situ*, and they germinated freely in water in twenty hours.

What is said to be the same fungus has been found on *Albizzia montana* Benth., in Java, and it would be interesting to know if it occurred on any indigenous species of this genus in New South Wales, Queensland or West Australia.

On *A. implexa* at Myrning there were numerous galls, and I found one at the end of a branch in July somewhat of a leg-of-mutton shape and weighing about 3 lbs. (Pl. XLI.). Witches' brooms of various sizes also occurred on *A. implexa*, caused by this rust, and one of the largest measured 45 inches in circumference (Pl. XLII.).

(Plates XXII., Figs. 190-195; XXIII., Fig. 206; XXXIV.; XXXV.; XLI.; XLII., Fig. 305.)

PUCCINIA Pers.

This genus includes more than half of all the Australian Rusts, and is important, not only on account of its numbers, but from its appearing on so many of our cultivated crops. It occurs on all the cereals and many of the grasses, on celery and chicory, on fruit trees, such as peach and plum, and many garden favorites are attacked by it, such as chrysanthemum and cornflower, hollyhock, marigold and daisy; even a parasite, such as the native mistletoe, is subject to it. The two-celled teleutospore is easily recognized and distinguished from the unicellular uredospore. All the spore-forms may be present on the one plant, as in *P. hederaceae* on the native violets (*Viola hederacea* and *V. betonicifolia*), or reduced to the teleutospore alone, as in *P. malvacearum*. There may also be heteroecious forms, such as *P. caricis*, with the aecidial stage on the nettle (*Urtica*). The teleutospore, although normally two celled, and with a horizontal septum, is sometimes very variable in these respects. It may not only, occasionally, be one-celled, but in *P. dichondrae*, for instance, it may be 3-4 celled, and it may be vertically, obliquely, or even muriformly divided by the septa. The most celebrated of all the species is *P. graminis*, or wheat rust, which seems to have lost the power here of infecting the barberry, for although germinating promycelial spores have been used upon specially imported barberries and rusty wheat grown around the latter, still no aecidia have been produced.

Mesospores are common and paraphyses may be present in both the uredo and teleuto-layer.

General characters.—Spermogonia when present, mostly epiphyllous, minute, sub-globose or flask-shaped, honey-coloured.

Spermatia very minute, globose or ellipsoid, hyaline.

Aecidia when present at first globose and closed, then cup-shaped and open, or elongated and cylindrical, with margins generally everted.

Aecidiospores originating in serial order and soon free, globose, sub-globose or angular, hyaline, yellowish or orange.

Uredosori when present, generally minute and flattened, sometimes paraphysate.

Uredospores globose, sub-globose, ellipsoid or ovate, originating singly on the terminal ends of the hyphae, with germ-pores mostly in pairs or several, rarely one, never smooth.

Teleutosori variable in size, flattened or pulvinate, sometimes paraphysate.

Teleutospores separate, variously shaped, pedicellate, 1-septate, with one germ-pore in each cell.

Sporidiola ovoid or reniform, generally hyaline.

Australian species, 90.

GRAMINEAE.

Agropyron, Clematis.

34. *Puccinia agropyri* Ell. & Ev.

Ellis and Everhart, Journ. Myc. VII., p. 131 (1892).

Sydow, Mon. Ured. I., p. 823 (1904).

Sacc. Syll. XI., p. 201 (1895).

Aecidium clematidis DC. Fl. franc. II., p. 243 (1805).

O. *Spermogonia* amphigenous, honey-coloured, in clusters on leaves, accompanying aecidia.

Spermatia hyaline, globose, minute, $3\ \mu$ diam.

I. Aecidia hypophyllous, on definite spots, bright orange, in irregular clusters; pseudoperidia cup-shaped, flattened, with reflexed lobed margin; peridial cells piriform to quadrate, striated at margin and punctate all over, $28-32 \times 16-22\ \mu$.

Aecidiospores orange-yellow, ellipsoid to sub-globose, finely echinulate, $21-29 \times 16-19\ \mu$, or $20-22\ \mu$ diam.

II. Uredosori epiphyllous, rarely on under surface, minute, elliptic or linear, sometimes confluent, yellowish to orange.

Uredospores orange yellow, elliptical to ovoid, finely echinulate, 4-5 scattered germ-pores on one face, $25-32 \times 19-22\ \mu$, episore up to $2\frac{1}{2}\ \mu$ thick.

III. Teleutosori hypophyllous, minute, covered by the leaden-coloured epidermis, at length occasionally erumpent, oblong or linear, sometimes forming lines on sheaths.

Teleutospores yellowish brown, cylindric clavate to elongated oblong, smooth, slightly constricted at septum, variable in size, $40-70 \times 12-25\ \mu$, average $60 \times 18\ \mu$; upper cell rounded or squarely truncate at apex and decidedly thickened ($6-9\ \mu$), sometimes broader than long, darker in colour than lower, $19-29 \times 16-25\ \mu$; lower cell tapering towards pedicel or oblong, usually longer and narrower than upper, $25-41 \times 12-20\ \mu$; pedicel short, generally tinted. Occasionally three-celled teleutospores occur.

X. Mesospores occasional, pale brown, elongated, rounded, or slightly pointed and thickened at apex, slightly tapering towards base, $40-48 \times 13-16\ \mu$, with short coloured pedicels.

Aecidiospores on *Clematis aristata* R. Br.

Victoria.—Murrumbidgee Ranges, Dec., 1903, and Jan., 1905 (Robinson).

Uredo and teleutospores on *Agropyron scabrum* Beauv.

Victoria.—Near Melbourne, Dec., 1892 (Robinson). Myrniong, March, Nov., Dec., Jan. Murrumbidgee Ranges, Dec., 1903 (Robinson).

The teleutospores vary considerably in size and shape. They are sometimes elongated cylindric but usually cylindric clavate, the lower cell being comparatively narrow and tapering slightly towards base, while the upper cell is expanded and considerably flattened out at apex. The length may vary from 40–70 μ and the breadth from 12 μ (in lower cell) to 25 μ (in upper cell). It is noticeable that certain sori may consist of elongated and others of medium-sized spores.

In the *Agricultural Gazette* for New South Wales, Vol. VI., p. 852, 1895, the rust on this native grass was given as *P. dispersa* Eriks. and Henn., but on further examination I find that it approaches most closely to *P. agropyri* Ell. and Ev. and is named accordingly.

Specimens of *P. agropyrina* Eriks., were examined from Eriks. Exs. 419 on *Agropyron repens* Beauv., and the uredospores measured 21–24 μ diam. or 24–27 \times 16–21 μ . The teleutospores, however, were considerably smaller than our own material, measuring only 33–42 \times 12–18 μ , average 39 \times 15 μ .

The following table will show at a glance the different sizes of the spores on different hosts of the two species of rust :—

	Uredospore.	Teleutospore.
<i>P. agropyrina</i> Eriks. on <i>Agropyron repens</i> , Beauv.	16–25 μ diam.	36–41 \times 13–16 μ
<i>P. agropyri</i> Ell. & Ev. on <i>A. glaucum</i> , Roem & Schult.	20–25 \times 18–22 μ	60–75 \times 20–25 μ
<i>P. agropyri</i> Ell. & Ev. on <i>A. scabrum</i> , Beauv.	25–32 \times 19–22 μ	40–70 \times 12–25 μ

Although the uredospores are described as smooth by Ellis and Everhart yet in specimens from Sydow's Ured. Exs. 1362, they are seen to be decidedly echinulate and it is a question whether such a thing as a smooth uredospore exists among Puccinias. The species altogether is of the *P. dispersa* type. Dietel⁴ infected *Clematis vitalba* with the germinating teleutospores of this species and produced spermogonia and aecidia (*A. clematidis* DC.) so that it is considered to be a heteroecious species and called by Klebahn,¹ p. 292, *Puccinia (clematidi) agropyri* Ell. and Ev. It is suggestive that both stages have been found in the Murramurrangbong Ranges growing near to each other.

(Plate III., Fig. 25.)

Deyeuxia.

35. *Puccinia agrostidis* Plow.

Plowright, Grev. XXI., p. 110 (1893) and Gard. Chron., p. 139 (1890).

McAlpine, Agr. Gaz. N.S.W. VII., p. 149 (1896).

Sydow, Mon. Ured. I., p. 717 (1903).

Sacc. Syll. XI., p. 202 (1895).

II. Uredosori elliptical to elongated, soon naked, linear and confluent.

Uredospores orange yellow, elliptical, finely echinulate, as many as 9 germ-pores seen on one face, forming a circle inside epispore, 22–24 \times 17–18 μ .

III. Teleutosori minute, black to dark-brown, long covered by the epidermis, sometimes elongate, sometimes in groups.

Teleutospores dark-brown, smooth, oblong or subclavate, apex thickened (up to 5 μ), truncate or rounded, markedly constricted, attenuated below, almost sessile, very shortly stalked, 40–54 \times 14–21 μ , average 44 \times 18 μ .

- X. Mesospores fairly numerous, similarly coloured to teleutospores or lighter, oval to elongated elliptical, thickened at apex, $24-30 \times 12-14 \mu$.

On *Deyeuxia forsteri* Kunth. = *Agrostis solandri*, F.v.M.

Victoria—Near Melbourne, 1892 (Robinson). Ardmona, Oct.–Dec., 1894 (Robinson). Arthur's Creek, Aug., 1902 (Robinson).

New South Wales—(Cobb²).

Through the kindness of Dr. Plowright, I received some of the original material, and there is a general agreement in the spores.

Dr. Cobb has described and drawn an unnamed species of *Puccinia* on *Deyeuxia forsteri*, which undoubtedly belongs to the same species. The teleutospores are given as $44-58 \times 16-22 \mu$, but the uredospores are rather larger, being $25-30 \times 21-25 \mu$.

The life-history of this species was made out by Dr. Plowright, who found after several experimental cultures, that the teleutospores produced *Aecidium aquilegiae* Pers. on *Aquilegia vulgaris*, and that the spores of *A. aquilegiae* when applied to *Agrostis alba* and *Poa pratensis* produced the rust.

(Plate III., Fig. 27.)

Anthoxanthum.

36. *Puccinia anthoxanthi* Fckl.

Fuekel, Symb. Myc. II., p. 15 (1873).

McAlpine, Agr. Gaz. N.S.W. VII., p. 301 (1896).

Sydow, Mon. Ured. I., p. 727 (1903).

Sacc. Syll. VII., p. 665 (1888).

- II. Uredosori on both surfaces of leaves, solitary or in elongated groups, elliptic or linear, confluent in lines, soon naked, pulverulent, dusky orange.

Uredospores yellowish-orange, elliptic to obovate, finely echinulate, with two to four very distinct equatorial germ-pores on one face, $25-32 \times 15-20 \mu$.

- III. Teleutosori scattered, minute, dark-brown to black, elliptic, naked, surrounded by ruptured epidermis.

Teleutospores at first intermixed with uredospores, chestnut-brown, elliptic to obovate or oblong-clavate, smooth, slightly constricted, rounded and thickened (6μ) at apex, occasionally tricellular, $28-48 \times 15-21 \mu$, average 35×20 ; upper cell usually darker than lower; pedicel persistent, tinted, $20-25 \times 6-7 \mu$, sometimes reaching a breadth of 10μ .

- X. Mesospores occasional, similarly coloured to teleutospores, obovate, thickened at apex, average $35 \times 17 \mu$.

On sheath, flag and inflorescence of *Anthoxanthum odoratum* L.

Victoria—Near Melbourne, Dec., 1896, II. Rutherglen, Dec., 1903, II., III. Leongatha, Feb., 1904., II.

The teleutospores were not very common. In my own garden, near Melbourne, the uredo-stage was plentiful, but no teleutospores were found, while at Rutherglen the teleuto-stage occurred on several specimens.

(Plate III., Figs. 20, 21.)

37. *Puccinia beckmanniae* McAlp.

- II. Uredosori on both surfaces of leaf, but most common on under, orange, elliptic, often confluent in lines, erumpent and surrounded by ruptured epidermis.

Uredospores orange, elliptic, echinulate, with 3 to 4 equatorial germ pores on one face, $25-29 \times 16-19 \mu$.

- III. Teleutosori minute, black, linear, hypophyllous, long covered by epidermis, ultimately naked, about $\frac{1}{2}$ mm. long.

Teleutospores yellowish-brown, elongated clavate, not or only slightly constricted at septum, upper cell generally darker than lower and with numerous (up to 7) finger like processes, $45-60 \times 16-25 \mu$, average 56×18 ; pedicel very short or absent.

- X. Mesospores brown, oblong to elongated elliptical, thickened at apex, and either bare or with short stumpy processes, $32-35 \times 13-16 \mu$.

On *Beckmannia erucaeformis* Host.

Victoria—Leongatha, February, March, 1904, II., III.

Only uredospores were met with in February, but by March the teleutospores had developed. There is a general agreement with *P. lolii*, but the upper cell of teleutospore is generally broader.

The grass on which this rust was found was grown from seed sent by the United States Department of Agriculture for trial, and the spores must have been imported with the seed. Holway informs me that he has collected it in the State of Minnesota, and kindly forwarded me a specimen.

Darluca filum Cast., was very plentiful, both by itself and in conjunction with the rust. Probably in the former case it was parasitic on the hidden mycelium, and may have largely prevented spore formation.

(Plate II., Fig. 12.)

38. *Puccinia bromina* Eriks.

Eriksson, Ann. Sci. Nat. IX., p. 271 (1899).

Sydow, Mon. Ured. I., p. 712 (1903).

Sacc. Syll. XVII., p. 382 (1905).

Puccinia dispersa, f. sp. *bromi*, Eriks.

- II. Uredosori 1-10mm. long, 1mm. broad, ferruginous, on leaf blade chiefly on upper surface, crowded, sometimes on sheath and panicle.

Uredospores bright orange, ellipsoid, with numerous scattered germ-pores, as many as 11 on one face, echinulate, $27-31 \times 18-24 \mu$.

- III. Teleutosori elongated elliptical to oblong, black to dark-brown, hypophyllous, scattered or subgregarious, sometimes on sheath and panicle, covered by epidermis, divided into compartments, and each compartment separated by elongated, cylindric, or slightly clavate, yellowish-brown, barren filaments or paraphyses.

Teleutospores oblong to clavate, dark chestnut-brown, constricted at septum, rounded or truncate at apex and slightly thickened, $40-56 \times 18-24 \mu$, average $48 \times 21 \mu$; lower cell generally narrower than and almost as dark as upper; pedicel short, hyaline to pale yellowish, up to 36μ long.

- X. Mesospores comparatively rare, dark chestnut-brown like teleutospores, clavate, oval or oblong, rounded or truncate and slightly thickened at apex, base sometimes attenuated, $28-36 \times 16-21 \mu$.

On *Bromus mollis* L.

Victoria—Nalinga, Nov., 1898 (Robinson). Kergunyah, Nov., 1902, Dec., 1903, and Jan., 1905 (Robinson). Domain, Melbourne, Dec., 1904, II., III., the latter very plentiful. Nagambie, Nov., 1904.

New South Wales—1890 (Cobb²).

On *Bromus arenarius* Labill.

Victoria—Murray River.

The specimen of *B. arenarius* in the National Herbarium attacked by an *Ustilago* and numbered Berkeley 202, also shows this rust, which, however, was overlooked. It is interesting as probably indicating that this is a native rust, although it also occurs on the imported *B. mollis*.

Three-celled teleutospores are occasionally met with, sometimes owing to the upper cell being divided vertically, but more frequently there are two transverse septa instead of one.

Specimens were examined from Eriksson's Fung. Paras. Scand., Exs. 420, and the uredospores measured $20-25 \times 17-20 \mu$; thus being rather smaller than the above. The teleutospores were much paler in colour, and measured $36-48 \times 15-22 \mu$, the largest being about the average of the Victorian specimens.

Fritz-Muller¹ observed aecidia on *Symphytum officinale* L. and *Pulmonaria montana* Lej., and by infection with the aecidiospores produced the rust on *Bromus*. He therefore named it *Puccinia symphyti bromorum*.

(Plate III., Fig. 28; Plate C., Figs. 11-13.)

Rottboellia.

39. *Puccinia cacao* McAlp.

Uredo rottboelliae Dietel, Engler's Bot. Jahrb. XXXII., p. 52 (1902).

Sori on both surfaces of leaves but mostly on under, scattered or in small groups, minute, elliptical, bullate, long covered by epidermis, about $\frac{1}{2}$ mm. long.

- II. Uredospores brownish or chocolate brown, elliptic to ovoid or oblong, with distinct germ-pores, generally three equatorial on one face or may be scattered, epispore thin, dark-coloured, finely echinulate, $32-40 \times 24-32 \mu$, average $35 \times 28 \mu$.

- III. Teleutospores intermixed with uredospores, sparse, somewhat paler, oblong, smooth, rounded or flattened and unthickened at apex, slightly constricted at septum, $32-35 \times 21-22 \mu$; lower cell tapering slightly towards base and generally about equal in size to upper; pedicel hyaline, deciduous.

On leaves and sheaths of *Rottboellia compressa* L.

Victoria—Creswick, Jan., 1893, II. (Robinson), Werribee Gorge, Dec., 1902, II. Killara, March, 1903, II., III. (Robinson). Kergunyah, Dec., 1903, II. (Robinson). Near Melbourne, Nov. and Jan., 1904. Various other localities.

Queensland—II. (Bailey¹⁷).

The Queensland specimen is labelled *Puccinia straminis* DeBary.

The chocolate-brown colour of the uredospores is very characteristic. The uredo-stage of this species was first described by Dietel on a specimen from Japan; on sending him some of our material he agreed that it was the same. Sydow in his Monograph (p. 800) has described a *Puccinia* on *R. arundinacea* with teleutospores alone, which however do not agree with these, being thickened at the apex up to 10 μ and $34-56 \times 22-27 \mu$ in size.

The uredosori frequently look quite black owing to the presence of *Darluca filum* Cast.

(Plate XXX., Figs. 259, 260.)

Cynodon.

40. *Puccinia cynodontis* Desm.

Desmazieres Exsicc. III., No. 655.

McAlpine, Agr. Gaz. N.S.W. VII., p. 150 (1896).

Sydow, Mon. Ured. I., p. 748 (1903).

Sacc. Syll. VII., p. 661 (1888).

P. altera McAlp., Agr. Gaz. N.S.W. VII., p. 151 (1896).

- II. Uredo-sori on both surfaces, minute, ellipsoid to lenticular, scattered or confluent, yellowish-brown to rusty-brown, soon naked, compact.

Uredospores globose to shortly elliptical, yellowish-brown to brownish-yellow, delicately verrucose, 20–25 μ diam., or $20-25 \times 17-22 \mu$.

- III. Teleutosori roundish to ellipsoid or oblong, scattered or confluent, pulvinate, black.

Teleutospores intermixed with uredospores, variously shaped, ellipsoid or oblong, smooth, chestnut-brown, slightly constricted at septum, occasionally tricellular, $30-50 \times 15-21$, average $35 \times 21 \mu$; upper cell thickened at apex and generally elongated pointed, sometimes rounded; lower cell rounded at base or attenuated; pedicel firm, pale yellow, persistent, elongated up to 73 μ .

- X. Mesospores plentiful, dark-brown, ellipsoid, rounded and thickened at apex, $24 \times 19 \mu$.

On *Cynodon dactylon* Pers.

Victoria—Burnley, Caulfield, Armadale, Pakenham, Killara, Somerville, &c., Oct.–March.

On some plants the teleutospores were of a very regular ellipsoid shape, and rounded and thickened at apex, so that it was at first thought there were two species on the same plant. But on examining a number of specimens every gradation was found from the teleutospore, rather constant in size and shape with rounded apex, to those necessarily longer on which the thickened apex was somewhat conical.

It was likewise found by Magnus⁵ that two kinds of uredospores occur, the one thin-walled with numerous (up to 9) germ-pores and echinulate, while the other is thick walled, with few (1-3) germ-pores and either smooth or only with a few scattered spines. There were transition forms between the two, and this shows how variable a description might be according to the nature of the spores regarded as typical.

(Plate III., Fig. 24.)

Festuca.

41. *Puccinia festucae* Plow.

Plowright in Gard. Chron., p. 42 (1890) and Grev. XXI., p. 109 (1893).

Sydow, Mon. Ured. I., p. 752 (1903).

Sacc. Syll. XI., p. 194 (1895).

- II. Uredosori mostly on under surface of leaf, but generally present on upper as well, causing conspicuous yellow spots on upper surface, minute, oblong to elliptic, scattered or confluent, orange-yellow.

Uredospores sub-globose to ellipsoid, echinulate, yellowish to orange-yellow, up to 5 scattered germ-spores on one face, $20-25 \times 16-18 \mu$.

- III. Teleutosori mostly on under surface of leaf, minute, scattered or often in groups and confluent, oblong to linear, brownish-black.

Teleutospores at first intermixed with uredospores, clavate to cylindrical, brown, smooth, slightly constricted at septum, generally tapering towards base, $40-60 \times 15-20 \mu$, often $60 \times 16 \mu$; upper cell more or less truncate and thickened at apex, surmounted by a crown of 4-6 obtuse, straight or curved, sometimes bifid processes; lower cell generally elongated wedge-shaped; pedicels persistent, brown, stout, $15-25 \mu$ long.

- X. Mesospores very common, similarly coloured to teleutospores, clavate to cylindrical to somewhat oblong, thickened at apex and surmounted by processes, $31-46 \times 11-14 \mu$.

On *Festuca ovina* L.

Victoria—Leongatha, July, 1903, II. III.

On *F. rigida* Kunth.

Victoria—Rutherglen, Nov., 1895, II.

In 1890 Plowright experimentally proved that the aecidium on Honey-suckle (*Lonicera*) was genetically connected with this species, and it has since been repeatedly proved by Fischer and Klebahn.

(Plate II., Fig. 13.)

Stipa.

42. *Puccinia flavescentis* McAlp.

McAlpine, Proc. Linn. Soc. N.S.W., XXVIII., p. 558 (1903).

Sacc. Syll. XVII., p. 380 (1905).

- II. Uredosori on upper surface of leaf, minute, linear, often confluent, soon naked, pulverulent, rusty brown, arranged along furrows of leaf.

Uredospores globose to shortly elliptical, finely echinulate, golden-brown, with at least 5 germ-pores irregularly distributed, $21-24\ \mu$ diam. or $25-32 \times 21-24\ \mu$.

III. Teleutosori minute, elliptical, numerous, black, often confluent lengthwise, soon naked.

Teleutospores intermixed with uredospores, dark chestnut brown, oblong, constricted at septum, with rounded and thickened apex (up to $9\ \mu$), smooth, occasionally tricellular, $33-48 \times 18-26\ \mu$, average $44 \times 24\ \mu$; upper cell generally hemispherical, and about equal in length to lower; lower cell generally rounded at base, sometimes narrowed and elongated like upper portion of pedicel; pedicel persistent, tinted, elongated, up to $72\ \mu$ long.

X. Mesospores common, similarly coloured to teleutospores, elongated ellipsoid, rounded or truncate and thickened at apex, smooth, $34-43 \times 12-15\ \mu$.

On *Stipa flavescent* Labill.

Victoria—Near Melbourne, Dec.—April, II., III.

On *Stipa semibarbata* R. Br.

Victoria—Nagambie, Nov., 1904, II., III.

The pulverulent uredosori, and the numerous minute, black teleutosori are characteristic of this species. The uredospores form a rusty powder over entire upper surface of leaf. The pedicel of the teleutospore is sometimes lateral and the septum erect as in *Diorchidium*. It differs from *P. stipae* Arthur, in the uredosori being soon naked and decidedly ruddy-brown, not yellowish, while the uredospores are broader.

In specimens of *P. stipae* (Op.) Hora, taken from Syd. Ured. Exs. No. 28, on *Stipa capillata* L., the teleutospores are decidedly different. The apex is generally bluntly pointed, and the size $48-54 \times 18-21\ \mu$. In specimens of *P. stipae* Arth., from Arthur and Holway's Ured. Exs. No. 27, on *Stipa spartea* Trin., the teleutospores are more pointed at the apex and rather thicker.

I have submitted specimens to Prof. J. C. Arthur, and he remarks that it is clearly distinct from his species, although there is very much similarity between the two, as one might expect, from the hosts being essentially alike.

(Plate II., Fig. 17.)

Gramineae.

43. *Puccinia graminis* Pers.

Persoon, Disp. Meth., p. 39 (1797).

Cooke, Handb. Austr. Fung., p. 335 (1892).

Sydow, Mon. Ured. I., p. 692 (1903).

Sacc. Syll. VII., p. 622 (1888).

II. Uredosori amphigenous, yellowish-brown, linear, 2-3 mm. or longer, either scattered or confluent in long streaks, especially on sheaths, pulverulent, soon naked, surrounded by ruptured epidermis.

Uredospores elongated ellipsoid to ovate oblong, brownish yellow, echinulate, generally with 3-4 equatorial germ-pores on one face, $20-36 \times 14-18 \mu$.

- III. Teleutospores sparingly on leaf-blades, more commonly on sheaths stalks and inflorescence, linear, elongated, pulvinate, often confluent, up to 10 mm. or more, dark brown to dense black, soon rupturing epidermis which is prominent.

Teleutospores clavate to oblong clavate, chestnut brown, smooth, somewhat constricted at septum, very rarely three-celled, $35-63 \times 14-25 \mu$, average $52 \times 18 \mu$; upper cell rounded or pointed at apex, rarely truncate, considerably thickened (up to 12μ), sometimes as broad as long, $21-29 \mu$ long; lower cell attenuated towards base, equal to or longer than upper, $18-35 \mu$ long; pedicel persistent, elongated, tinted, and sometimes as deeply coloured as spore, of equal thickness throughout, up to $73 \times 8 \mu$.

- X. Mesospores very common, intermixed in the same sorus with uredo and teleutospores, similarly coloured, dark chestnut or paler, oblong to elongated ellipsoid, generally slender, rounded, pointed or truncated apex and thickened like teleutospore, smooth, $34-46 \times 10-15 \mu$; pedicel generally short or of moderate length. Occasionally an obovate form occurs, deeply coloured, rounded and thickened at apex and much broader than usual, up to 22μ , with elongated pedicel.

On Wheat (*Triticum vulgare* Vill.), Polish Wheat (*T. polonicum* L.), Oats (*Avena sativa* L.), Barley (*Hordeum vulgare* L.), Rye (*Secale cereale* L.), and various species of the following genera of Grasses:—*Agropyron*, *Alopecurus*, *Amphibromus*, *Avena*, *Beckmannia*, *Briza*, *Bromus*, *Dactylis*, *Deyouzia*, *Echinopogon*, *Elymus*, *Festuca*, *Glyceria*, *Hordeum*, *Phalaris*, *Poa*.

Common in all the States.

Occasionally I have seen a uredospore with a slight indentation on either side, just where the circle of germ-pores occurs, but never any indications of a septum. The range of variation in the size of the teleutospores is great. It may vary from $35 \times 25 \mu$ in the oblong, dark-brown, perfectly mature spore to 63μ , long, and sometimes only 14μ broad in elongated clavate spores in the same sorus.

The spore itself may be colourless, while the brown colouration is in the pedicel, and this has previously been observed by Dr. Plowright in Australian specimens; or the upper cell only may be pale in colour as shown in Plate I, Fig. 8, which is from abnormal material met with on one occasion.

There are no paraphyses, but there are numerous mesospores closely resembling teleutospores, but only one-celled.

Darluka filum Cast., sometimes common on the uredosori, particularly on Wild Oat (*Avena fatua*) and *Glyceria stricta*. It has also been found on *Agropyron scabrum*, and Dr. Cobb⁵ evidently mistook its true nature, for he says:—"Among its red-rust spots there are certain black bodies which may constitute a fourth spore of the rust."

The following is a complete list of all the grasses and cereals on which I have found *Puccinia graminis* Pers. This determination of the fungus has been based on morphological characters alone, for I have not yet succeeded in infecting the Barberry. Those marked with an * are also recorded by

other authors, and a double asterisk indicates those which have been found by Eriksson in Europe to produce aecidia on the Barberry when their spores were sown upon it:—

Agropyron divergens Nees	...	...	...	II., III.
*A. scabrum Beauv.	...	...	...	II., III.
Alopecurus geniculatus L.	...	...	...	II.
Amphibromus neesii Steud.	...	...	...	II., III.
*Avena fatua L.	...	...	...	II., III.
**A. sativa L.	...	...	...	II., III.
Beckmannia erucaeformis Host.	...	...	...	II., III.
*Briza minor L.	...	...	...	II.
Bromus racemosus L.	...	...	...	II.
**B. secalinus L.	...	...	...	II.
B. sterilis L.	...	...	...	II., III.
**Dactylis glomerata L.	...	...	...	II., III.
Deyeuxia quadriseta Benth.	...	...	...	II., III.
Echinopogon ovatus Beauv.	...	...	...	II., III.
Elymus striatus Willd.	...	...	...	II.
E. virginicus L.	...	...	...	II., III.
Festuca bromoides L.	...	...	...	II., III.
Glyceria dives F.v.M.	...	...	...	II., III.
G. stricta Hook.f.	...	...	...	II.
**Hordeum murinum L.	...	...	...	II., III.
H. secalinum Schreb.	...	...	...	II., III.
**H. vulgare L.	...	...	...	II., III.
*Phalaris canariensis L.	...	...	...	II., III.
P. minor Retz.	...	...	...	II., III.
**Secale cereale L.	...	...	...	II., III.
Triticum polonicum L.	...	...	...	II., III.
**T. vulgare Vill.	...	...	...	II., III.

While *P. graminis* has been found on the above grasses, it must not be assumed that the one will affect the other if growing alongside of each other. It used to be considered that the same species would attack indiscriminately any of its hosts, but it has now been proved that a selection or specialisation goes on, and that the same morphological species living on different hosts is not identical in the sense of affecting all alike. By means of infection experiments with uredospores and aecidiospores obtained from definite teleutospores, Eriksson arrived at this result, that *P. graminis* resolved itself into a series of specialised forms, each of which was confined to a definite and circumscribed series of host-plants.

As the result of experiments so far, six biologically distinct forms are constituted:—

1. Secalis—On Rye.
2. Avenae—On Oat.
3. Tritici—On Wheat.
4. Airae—On Aira.
5. Agrostidis—On Agrostis.
6. Poae—On Poa.

When time and opportunity offer, I hope to carry out experiments to determine how far the rusts of the *P. graminis* type on the various grasses are capable of infecting each other.

(Plates I., Figs. 2, 5, 7, 8; XIV., Figs. 113-122; XL., Fig. 301; XLIII., Fig. 311; Plate A., Figs. 3, 4.)

*Elymus.*44. *Puccinia impatientis* (Schw.) Arthur.

Arthur, Bot. Gaz. XXXV., p. 19 (1903).

Sydow, Mon. Ured. I., p. 751 (1903).

Aecidium impatientis Schw.

- II. Uredosori epiphyllous and occasionally hypophyllous, scattered or arranged in lines and confluent, oblong, $1-1\frac{1}{2}$ mm. long, pulvinate, erumpent, powdery, reddish-brown.

Uredospores bright orange, subglobose or ellipsoid, finely echinulate, up to six scattered germ-pores on one face, $25-33 \times 18-23 \mu$.

- III. Teleutosori hypophyllous, greyish-black, pulvinate, long covered by epidermis, densely crowded, linear, often confluent and arranged in lines between the veins, with dark-brown paraphyses in clusters.

Teleutospores brownish, oblong to oblong-clavate, smooth, slightly constricted at septum, $35-55 \times 16-22 \mu$, average $40 \times 16 \mu$; upper cell rounded or truncate, and thickened at apex ($3-5 \mu$); lower cell generally paler in colour, and rounded or attenuated at base; pedicel very short, hyaline or tinted, but dark-brown at apex.

- X. Mesospores not uncommon, pale brown, slightly thickened at apex, elongated, oblong, or obovoid, $29-35 \times 12-17 \mu$.

On living leaves of *Elymus condensatus* Presl.

Victoria—Rutherglen, Dec., 1903.

The seed of this grass was obtained from the United States, and the rust was doubtless imported with it.

Arthur sowed germinating teleutospores from *Elymus virginicus* L. on *Impatiens aurea* Muhl., and in fifteen days aecidia were produced. This result was confirmed in the succeeding year.

Specimens on *E. virginicus*, from Iowa, in Sydow's Ured. Exs. 1380, are labelled *Puccinia rubigovera* (DC.) Wint., and agree with this species.

There is another *Puccinia* on the same host plant (*P. procera* Diet. and Holw.), and according to the description it is quite distinct. The uredospores are $32-45 \times 30-38 \mu$ and the teleutospores $45-100 \mu$ long.

P. montanensis Ellis also differs in the teleutospores being stouter and broader, sometimes reaching a breadth of 26μ .

(Plate III., Fig. 26.)

*Lolium.*45. *Puccinia lolii* Niels.

Nielsen in Ugeskrift for Landmaend. I., p. 549 (1875).

Sydow, Mon. Ured. I., p. 704 (1903).

Sacc. Syll. XI., p. 203 (1895).

P. coronifera Klebahn, Zeitschr. f. Pflanzenk. II., p. 340 (1892).

- II Uredosori on upper and under surfaces of leaves, forming blister-like swellings, oval or linear, orange, soon bursting through epidermis, pulverulent, often confluent, sometimes up to 2 mm. long.

Uredospores orange-yellow, subglobose, ovate or broadly elliptic, strongly echinulate, with 2-3 equatorial germ-pores on one face, $20-30 \times 16-24 \mu$; occasionally a few colourless capitate paraphyses intermixed.

III. Teleutosori on both surfaces of leaves, minute, black, linear or oblong, often confluent, long covered by epidermis, $\frac{1}{2}$ -1 mm. long.

Teleutospores yellowish-brown to brown, elongated, clavate, tapering towards base, smooth, constriction very slight or absent, sometimes unicellular, $35-60 \times 12-20 \mu$, average $53 \times 16 \mu$; upper cell brown, truncate, thickened at apex, giving off irregular, blunt, generally curved processes variable in size and shape, averaging 6 to 7 or more; lower cell generally paler in colour, longer than upper, and attenuated towards base; pedicel persistent, coloured, short, stout, up to 11μ long by 8μ broad.

X. Mesospores exactly resembling teleutospores only one-celled.

On stem, leaf, and inflorescence of *Lolium perenne* L. Common.

Victoria—Near Melbourne, Myrniong, Port Fairy, &c., Aug.—May.
South Australia—Mount Gambier, April, 1903, II., III.

The teleutospores may be found as early as September, and through the summer and autumn.

In some districts this rust is very severe and kills the grass down to the roots, especially if there are early autumn rains and warm weather.

Darlucium filum Cast., on uredosori.

Puccinia lolii avenae.

On *Avena sativa* L., and *Avena fatua* L.

Victoria—Port Fairy, Dec. 1903, and Sept.—Nov. 1904, II., III.
Brighton, Jan., 1904, II., III. Myrniong, Nov., 1904, II.
Near Melbourne, Jan., 1905, II., III.

New South Wales—(Cobb¹²).

Eriksson has shown that the form occurring on *Lolium* will not infect *Avena*, nor the reverse, so that there are two biologic forms, and that found on the Oat may be distinguished as *P. lolii avenae*.

This species may occur alongside of *P. graminis*, and the teleutosori were found together on the sheath of the cultivated oat, *A. sativa*, and the wild oat, *A. fatua*.

The teleutospores on the wild oat are sometimes very much longer than the normal. They range from 70 to 86 μ in length, and from 18-22 μ in breadth at the apex, and 7-8 μ at the base.

By infection experiments Klebahn² proved the connexion between this rust, and the aecidium on *Rhamnus frangula* L., but this genus does not occur naturally in Australia.

P. coronata Corda, was the name originally given to the species occurring on *Lolium perenne*, *Avena sativa*, &c., with teleutospores surmounted by a crown of finger-like processes. It was found by culture experiments that the aecidial stage was produced on species of *Rhamnus*, and Klebahn determined that the spores from some species of grasses produced aecidia exclusively on *Rhamnus cathartica*, while others did so exclusively on *R. frangula*. This showed a biological distinction between the two, and Klebahn proposed the name of *P. coronifera* for the rust producing aecidia

on *Rhamnus cathartica*, while the original name was retained for the rust producing its aecidia on *Rhamnus frangula*. Nielsen had previously used the name of *P. lolii* for Klebahn's species, and so it is retained on the score of priority.

(Plate II., Figs. 11, 14 ; Plate XXX., Fig. 261 ; Plate B., Figs. 5-8.)

Phragmites.

46. *Puccinia magnusiana* Koern.

Koernicke, Hedw. XV., p. 179 (1876).

Sydow, Mon. Ured. I., p. 785 (1904).

Sacc. Syll. VII., p. 631 (1880).

- II. Uredosori on both surfaces of leaf, but mostly on upper, snuffy brown, erumpent, surrounded by ruptured epidermis, elliptic or linear, confluent lengthwise and forming long streaks, with clavate bright yellow paraphyses.

Uredospores elliptic or obovate, golden yellow, echinulate, with four equatorial germ-pores, $24-35 \times 16-19 \mu$; intermixed with large numbers of clavate paraphyses, club thickened at apex, of a dark smoky-brown and stalk hyaline, commonly $80-90 \mu$ long.

- III. Teleutosori minute, black, very numerous, scattered, elliptic or linear, confluent into long black streaks on both surfaces of leaf, but mostly on upper, occasionally paraphysate as in uredosori.

Teleutospores clavate to oblong, dark chestnut-brown, generally rounded and thickened at apex (up to 12μ), sometimes bluntly pointed, hardly constricted at septum, $35-55 \times 14-21 \mu$, average $38 \times 18 \mu$; lower cell attenuated towards base; pedicels firm, persistent, coloured yellowish, about length of spore or longer, up to 70μ .

- X. Mesospores similarly coloured to teleutospores, variable in shape, somewhat ovoid to elongated, thickened at apex, $28-38 \times 13-19 \mu$.

On *Phragmites communis* Trin.

Victoria—Orbost, Aug., 1901 (Pescott). Flinders, Jan., 1902.

Port Fairy, June-Aug., 1902 and 1905. Killara, March, 1903. Bunyip, May, 1904.

South Australia—The Grange, April, 1891 (Tepper). River Torrens, Adelaide, Apr., 1903 (Tepper).

Tasmania—(Rodway ¹).

The clavate paraphyses are usually described as hyaline, but Dr. Dietel compared the Australian specimens with intense dark-brown paraphyses with material from Europe, America, and the Cape of Good Hope, and he found that the latter were sometimes scarcely coloured, at other times light or dark brown.

The rust on *Phragmites communis* Trin., was considered as one species up to 1876, viz., *Puccinia phragmitis* Schum. Then Koernicke separated it into two, viz., *P. phragmitis* and *P. magnusiana*. The former was characterized by the absence of paraphyses from the uredosori, the large bullate teleutosori and the very long stalked markedly constricted teleutospores, while the latter had numerous clavate paraphyses in the uredosori, minute, punctiform or linear teleutosori, and shortly stalked, hardly constricted teleutospores. The aecidia in the two cases likewise occurred on different hosts.

Subsequent research showed that there were still other species on the same host-plant. Plowright separated a third species in 1888, mainly based upon the fact that the aecidiospores were only produced upon *Rumex acetosa* and not upon other plants. Next, Ludwig in 1892 distinguished another new rust on material sent from South Australia, viz., *P. tepperi*. Finally, Arthur in 1902 published another new species which he named *P. simillima* because it was very similar to *P. magnusiana*.

There are thus at least five different species of *Puccinia* recorded upon *Phragmites communis*, and it is not always easy to differentiate them, at least by morphological characters. In three of them the aecidiospores were proved to occur on different host-plants by a series of cultures, and this is considered by many a sufficient specific distinction. On these grounds they would be considered biological species as in the case of *Puccinias* on various cereals and grasses, but at the same time an attempt will be made here to show any points in which they differ morphologically. Only two of the five have hitherto been found in Australia, viz., *P. magnusiana* and *P. tepperi*, for although Dr. Cooke gives *P. phragmitis* in his *Handbook of Australian Fungi*, it was probably intended for *P. magnusiana*, which has been found in Victoria and South Australia.

The life-history of this fungus was first determined by Dr. Plowright,⁵ who found that the promycelial spores produced aecidia on *Ranunculus repens* and *R. bulbosa*, and conversely the aecidiospores produced uredospores and teleutospores on *Phragmites*. This was afterwards confirmed by Fischer¹ and Klebahn.¹

The five species may be arranged according to their aecidial hosts where known, as in the following table with their special characteristics shown :—

Rumex sp. and Rheum.	Rumex acetosa.	?	Ranunculus repens and R. bulbosa.	Anemone dichotoma.
Uredosori without paraphyses.			Uredosori with paraphyses.	
<i>P. phragmitis</i> .	<i>P. trailii</i> .	<i>P. tepperi</i> .	<i>P. magnusiana</i> .	<i>P. simillima</i> .
Uredospores, 25-35 × 15-23 μ	25-35 × 20-25 μ	27-30 × 20-23 μ	24-35 × 16-19 μ	26-44 × 18-22 μ
Teleutospores, 45-65 × 16-25 μ markedly con- stricted	50-60 × 20-23 μ markedly con- stricted	45-68 × 18-26 μ markedly con- stricted	35-55 × 14-21 μ hardly con- stricted	42-56 × 15-20 μ hardly con- stricted
Pedicels, 150-200 μ long	75-100 μ long	180-250 μ long	About length of spore	About length of spore

It will be seen from the above that there are two types clearly distinguishable morphologically, paraphysate and aparaphysate, and within these limits there are only "biological species" based upon a difference of aecidial host.

If we compare *P. trailii* with *P. phragmitis*, the teleutospores differ in having a granular spore-membrane, and shorter and stouter pedicels. If a similar comparison is made of *P. tepperi*, the length of the pedicel is the striking feature, and it is, perhaps, rather premature to separate it from *P. phragmitis* until a distinct aecidial host has been proved.

According to Arthur, *P. simillima* is distinguished from *P. magnusiana* in the slender pointed teleutospores, the more clavate and less roughened uredospores and the probably different aecidial host, viz., *Anemone dichotoma* L.

*Zea.*47. *Puccinia maydis* Bereng.

Bereng., Atti VI., Riun. sc. ital., Milano, p. 475 (1844).

Cooke, Handb. Austr. Fung., p. 337 (1892).

Sydow, Mon. Ured. I., p. 830 (1904).

Sacc. Syll. VII., p. 659 (1888).

Puccinia sorghi (in part) Schweinitz, N. Amer. Fung., p. 295, (1831).

- II. Uredosori amphigenous, elliptic or oblong, scattered or united into larger or smaller groups, here and there confluent, rather convex, soon erumpent from the longitudinal fissure of the cuticle, reddish-brown.

Uredospores ellipsoid or obovate, slightly warted, at first yellowish then reddish brown, with two to three equatorial germ-pores on one face, $23-38 \times 20-26 \mu$.

- III. Teleutosori amphigenous, scattered or subgregarious, variable in form, mostly linear or oblong, long covered by epidermis, prominent, very black, 1-2 mm. long.

Teleutospores obovate to oblong or subclavate, bright chestnut brown, smooth, constricted at septum, rounded or conoid and thickened at apex (up to 8μ), sometimes truncate, rounded, base and rarely somewhat attenuated, occasionally 3 or 4 celled, $32-52 \times 16-24 \mu$, average $36 \times 20 \mu$; upper cell rarely vertically divided; epispore thick; pedicels persistent, elongated, yellowish, thickened particularly towards apex, up to 90μ long.

- X. Mesospores occasional, similarly coloured to teleutospores, ovoid, rounded at both ends, thickened at apex, average $35 \times 17 \mu$.

On leaves of *Zea mays* L.

Victoria.—Seville, April, 1897, II. (Hill). Tally Ho, April, 1902, II. (Cronin). Leongatha, March, 1904, II. Near Melbourne, April, 1904, II., III.

New South Wales.—Richmond (Cobb).

Queensland.—Toowoomba, 1887 (Tryon¹), (Bailey^{1,5}).

Schweinitz considered that the same rust occurred on sorghum and maize to which he gave the name of *P. sorghi*, but since they are now found to be distinct Sydow in his Monograph has reserved the above name for this one.

Arthur⁴ inoculated maize plants with uredospores from an aecidium on *Oxalis cymosa* Small, and in five days uredosori appeared in abundance. The *Oxalis* is supposed to have been inoculated from the teleutospores of *P. maydis*, but this infection has still to be verified.

Darlucal filum Cast., occurs on the uredosori.

(Plate II., Figs. 15, 16; Plate C., Figs. 14, 15.)

*Alopecurus.*48. *Puccinia perplexans* Plow.

Plowright, Quart. Journ. Micro. Sc. XXV., p. 164 (1885).

Sydow, Mon. Ured. I., p. 719 (1903).

Sacc. Syll. VII., p. 632 (1888).

- II. Uredosori amphigenous and on sheath, orange, elliptic, rupturing epidermis and often confluent in lines.

Uredospores orange-yellow, subglobose to elliptic, finely echinulate, with 4–6 scattered germ-pores on one face, $25\text{--}29 \times 19\text{--}22 \mu$.

- III. Teleutosori amphigenous and on sheath, covered by leaden-coloured epidermis, at first minute, linear, then confluent in very long lines and even forming patches.

Teleutospores variable in shape, clavate to oblong, constricted at septum, brown, upper cell darker than lower, rounded or truncate at apex and slightly thickened, lower cell attenuated towards base or rounded, $35\text{--}52 \times 16\text{--}24 \mu$, average $37 \times 17 \mu$; pedicel short, hyaline, may reach a length of 20μ .

- X. Mesospores common, similarly coloured to teleutospores, slightly thickened at apex, elliptic to ovate or pear-shaped, $25\text{--}32 \times 16\text{--}21 \mu$.

On *Alopecurus geniculatus* L.

Victoria—Minyip, Nov., 1903 (Eskert).

Among these plants one was badly rusted with the uredospores of *Puccinia graminis* but no trace of the teleutospores of that fungus was found, although all the specimens were growing together.

Plowright in a series of more than thirty cultures worked out the life-history of this fungus and showed the genetic connexion between the aecidium on *Ranunculus acris* and this species, which was afterwards confirmed by Dietel and Klebahn.

(Plate III., Fig. 23.)

Poa.

49. *Puccinia poarum* Niels.

Nielsen, Bot. Tids. II., p. 26 (1876).

Cooke, Handb. Austr. Fung., p. 336 (1892).

Sydow, Mon. Ured. I., p. 795 (1904).

Sacc. Syll. VII., p. 625 (1888).

- II. Uredosori small, round or elliptical, scattered or aggregated together, orange-yellow or foxy-red.

Uredospores shortly elliptical, finely echinulate, orange-yellow, $21\text{--}24 \times 15\text{--}18 \mu$, seated on hyaline pedicels up to 30μ long, and intermixed with numerous, stiff, capitate paraphyses, reaching a length of 68μ .

- III. Teleutosori small or large, scattered or orbicularly disposed, dark-brown to black, covered by the epidermis.

Teleutospores elliptical or subclavate, very variable, apex truncate, rounded or conical, thickened ($4\text{--}8 \mu$), dark-brown, smooth, not or hardly constricted at septum, $35\text{--}45 \times 15\text{--}21 \mu$, or may reach a length of 53μ when 3-celled, average $38 \times 19 \mu$; pedicels persistent, short, brown.

On leaves and stems of *Poa annua* L.

Victoria—Near Melbourne, Jan.–Dec., 1886, &c., II., III.

New South Wales—Sydney, 1890 (Cobb). Botanic Gardens, Sydney, May, 1898.

On *Poa caespitosa* Forst.

Victoria—Botanic Gardens, Melbourne, Dec., 1904.

On *Poa pratensis* L.

Victoria—Port Fairy, Sept., 1904. Near Melbourne, Sept., 1904.

Uredospores have been found all the year round and teleutospores from August to December. Teleutospores are fairly plentiful in October, and they are often three—or even four—celled. The three-celled forms have either transverse septa, or the upper cell may be divided vertically or slightly oblique. The four-celled is either produced by transverse septa, the upper one being usually oblique, or the upper third may be divided longitudinally. In these abnormal forms the length may reach $53\ \mu$ and the breadth $34\ \mu$ at the apex.

The genetic connexion between the aecidium on Coltsfoot (*Tussilago farfara*) and this rust was first shown by Nielsen in 1876 and repeated by Plowright in 1882, who found that the aecidiospores produced the uredospores on *Poa annua* in ten to twelve days. But the Coltsfoot does not exist in Australia, and, therefore, this rust can reproduce itself without the intervention of aecidia. As might be anticipated the uredo stage carries it over the winter, and, indeed, the fungus is most plentiful in our winter and early spring months—June, July, August, and September. *Poa annua* as a rule dies away early in October, as soon as the warm weather comes on, except in moist shady places. Lagerheim¹, has found the spores on the leaves after the melting of the snow.

Darluca filum Cast., commonly occurs.

(Plate III., Fig. 22.)

Sorghum.

50. *Puccinia purpurea* Cooke.

Cooke, Grev. V., p. 15 (1876).

Sydow, Mon. Ured. I., p. 803 (1888).

Sacc. Syll. VII., p. 657 (1888).

Uredo sorghi Fekl.

- II. Uredosori amphigenous, seated on indeterminate, elongated and confluent, bright red to purple spots, scattered or in small irregular groups, covered by epidermis, and then splitting, yellowish-brown, $1-1\frac{1}{2}$ mm. long.

Uredospores ellipsoid, obovate to piriform, yellowish-brown, roughly aculeate, with 3-4 germ-pores on one face, $28-34 \times 20-25\ \mu$, average $31 \times 21\ \mu$; paraphyses intermixed.

- [III. Teleutosori on similar spots, mostly hypophyllous, oblong, elliptic, or linear, always or long covered by epidermis, reddish-brown.

Teleutospores ellipsoid, oblong or ovate-oblong, rounded at apex, not or scarcely thickened, not or very slightly constricted at septum, mostly rounded at base, smooth, bright brown, with very thick epispore, $35-56 \times 22-32\ \mu$; pedicel hyaline, persistent, thick, up to $100\ \mu$ long; paraphyses present.]

On leaves of Johnson Grass (*Sorghum halepense* Pers.) and Sugar-cane (*S. vulgare* Pers.).

Queensland—Gladfield (Gwyther), Nerang (Shirley), (Bailey^{14, 15}).

Only uredospores have been met with here.

In *P. maydis* the teleutospores are thickened at apex. Originally *P. sorghi* Schwein. included rust on *Zea* and *Sorghum*, but it is now found that the same rust does not occur on both, and Sydow, in his Monograph, has wisely determined to reserve *P. purpurea* Cooke, for *Sorghum* and *P. maydis* Bereng., for *Zea*.

Darluca filum Cast., is very common on uredosori.

51. *Puccinia simplex* (Koern.) Eriks. and Henn.

Eriksson and Henning, *Getreider.* p. 238 (1896).

McAlpine, *Journ. Dep. Agr. Victoria I.*, pp. 430 and 529 (1902).

Sydow, *Mon. Ured. I.*, p. 756 (1903).

Sacc. *Syll. XVII.*, p. 377 (1905).

Puccinia straminis Fekl. var. *simplex* Koern. in *Land und Forstwirtsch. Zeit.* (1865).

- II. Uredosori very minute or up to $\frac{1}{2}$ mm. long, sparingly scattered or sometimes numerous on both surfaces of leaves, but mostly on upper, citron yellow.

Uredospores subglobose or ellipsoid, echinulate, yellow, relatively thick walled, with numerous scattered germ-pores, 4-7 on one face, 21-24 μ diam, or 24-30 \times 17-20 μ .

- III. Teleutosori covered by the epidermis, amphigenous, numerous, minute, punctiform, mostly oblong and confluent, black, somewhat longer on leaf sheath than on leaf, divided into compartments by brown paraphyses, often strongly enlarged and thickened towards, the apex and spread out horizontally.

Teleutospores oblong clavate to clavate, dark chestnut brown, smooth, usually rounded or truncate at apex, or obliquely conical, and slightly thickened at apex, but may sometimes reach 6 μ , and slightly constricted at septum, 40-54 \times 17-24 μ ; upper cell oblong, generally as broad as long, 15-21 \times 17-22 μ ; lower cell tapering towards pedicel, sometimes quite narrow at base, longer than upper, 21-33 \times 15-18 μ ; pedicel short, slightly tinted.

- X. Mesospores very numerous, similarly coloured and similarly thickened at apex to teleutospores, asymmetrical, sometimes elongated, saccate or inversely triangular, very variable, 24-45 \times 15-24 μ .

On *Hordeum vulgare* L.

Victoria—Port Fairy, Warrnambool, Nov.—Jan.

This form was first described in 1865 by Koernicke as a variety, but now Eriksson and Henning have raised it to the rank of a species.

A very characteristic feature of it is the great predominance of unicellular spores. A sorus may consist entirely of these or there may be a few normal teleutospores intermixed. They are produced alongside the two-celled forms, and are quite similar to them except that they are one-celled, and they evidently show the transition from the one-celled to the two-celled teleutospore. There is usually a slight thickening at the apex of both, but it rarely exceeds 4-6 μ . It was early recognised as an exceptional form, and was named *Uromyces hordei* by Nielsen in 1875, and *Puccinia anomala* by Rostrup in 1876.

The teleutospores only germinate after a period of rest, according to Eriksson and Henning¹.

*Distichlis.*52. *Puccinia subnitens* Diet.

Dietel, *Erythea*, p. 81 (1895).

- II. Uredosori hypophyllous, orange, powdery, soon naked and surrounded by ruptured epidermis, often in long lines and confluent, bullate.

Uredospores yellowish-brown, globose to slightly ellipsoid, densely echinulate, with 3-4 scattered germ-pores on one face, thick-walled, $21-23\ \mu$ diam. or $21-28 \times 18-20\ \mu$.

- III. Teleutosori similar to uredosori, but dark-brown.

Teleutospores intermixed with uredospores, dark chestnut-brown, oblong to clavate, rounded at both ends or slightly tapering towards base, slightly constricted at septum and thickened at apex ($4-7\ \mu$), smooth, $28-46 \times 19-23\ \mu$; pedicel persistent, yellow, up to $56\ \mu$ long.

- X. Mesospores not uncommon, similarly coloured to teleutospores, obovate, rounded and thickened at apex (up to $7\ \mu$), smooth, $28-37 \times 19-22\ \mu$; pedicel similar to that of teleutospore.

Darluca filum Cast., common on uredosori.

On living leaves of *Distichlis maritima* Rafin.

Victoria—Flinders, Jan., 1902. Near Melbourne, April and Nov., 1905, II., III. (Robinson).

This species is quite distinct from *P. distichlidis* E. and E., which, however, was originally found on *Spartina gracilis* Trin., the host-plant being mistaken for a *Distichlis*.

Arthur⁷ has obtained some remarkable results by sowing the teleutospores of this species derived from *Distichlis spicata* Greene, on various plants. The germinating teleutospores produced aecidia on three widely-separated families of plants, viz.—Chenopodiaceae, Capparidaceae, and Cruciferae.

According to the *Index Kewensis*, *D. spicata* is a synonym of *D. maritima*.

(Plate XXX., Figs. 262-264.)

*Phragmites.*53. *Puccinia tepperi* Ludw.

Ludwig, *Zeitschr. f. Pflanzenk.* II., p. 132 (1892).

Sydow, *Mon. Ured.*, I., p. 792 (1904).

Sacc. *Syll.* XI., p. 203 (1895).

- Sori epiphyllous, large, scattered or gregarious and confluent, up to 3 cm. long, firm, thick, pulvinate, erumpent, dark-brown; paraphyses in clusters, hyaline or pale yellow, capitate, thickened at apex, up to $75\ \mu$ long.

- II. Uredospores ellipsoid or pear-shaped, echinulate, pale yellowish, with as many as 9 scattered germ-pores on one face, $27-30 \times 20-23\ \mu$.

- III. Teleutospores intermixed with uredospores, subcylindrical to occasionally oblong, with rounded or acute slightly thickened apex ($4-5\ \mu$), markedly constricted at septum and upper cell often becoming detached, rounded or rarely attenuated at base, smooth, yellowish-brown, occasionally 3-4 celled, $45-68 \times 18-26\ \mu$, average $50 \times 19\ \mu$; pedicel hyaline, persistent, up to $250\ \mu$ long.

- X. Mesospores very rare, similarly coloured to teleutospores, elongated ellipsoid, rounded and slightly thickened at apex, tapering very slightly towards base, $58 \times 21 \mu$.

* On *Phragmites communis* Trin.

S. Australia—The Grange, near Adelaide, April, 1891 (Tepper) (Ludwig³).

The mesospores had all the appearance of teleutospores without the septum. The rounded apex and stalk at base showed that this was not the basal cell of a normal teleutospore.

(Plate II., Fig. 19.)

Triticum.

54. *Puccinia triticina* Eriks.

Eriksson, Ann. Sci. Nat. Series VIII., p. 270 (1899).

Sydow, Mon. Ured. I. p. 716 (1903).

Sacc. Syll. XVII., p. 376 (1905).

P. dispersa f. sp. *tritici* Eriks. and Henn., Zeitschr. f. Pflanzenk. IV., p. 257 (1894).

- II. Uredosori 1–2 mm. long, reddish-brown, amphigenous, but mostly on upper surface of leaf-blade, elliptic, sometimes confluent, scattered or somewhat gregarious, occasionally on sheath and stem.

Uredospores subglobose to shortly ellipsoid, echinulate, orange-yellow, 4–6 scattered germ-pores on one face, $20-28 \times 18-21 \mu$.

- III Teleutosori oblong, black to dark-brown, hypophyllous, scattered, often arranged lengthwise in lines, sometimes on sheath and stem, covered by epidermis, divided into compartments surrounded by brown paraphyses.

Teleutospores clavate to oblong, smooth, yellowish-brown to dark-brown, slightly constricted at septum, very occasionally 3-celled, $39-57 \times 15-18 \mu$, average $48 \times 16 \mu$; upper cell deeply coloured, generally rounded or flattened at apex and thickened, $17-31 \times 15-18 \mu$; lower cell paler and attenuated towards pedicel, longer and narrower than upper, $22-36 \times 12-14 \mu$; pedicel short, coloured.

- X. Mesospores occasional, similarly coloured to teleutospores, ellipsoid to clavate or sub-clavate, shortly stalked, smooth, slightly thickened at apex, $25-38 \times 13-16 \mu$.

On wheat, *Triticum vulgare* Vill. and *T. polonicum* L. Common.

Victoria, New South Wales, Queensland, South Australia, West Australia, and Tasmania.

The uredospores are distinctly different from those of *P. graminis* in being subglobose instead of elongated, and the more numerous germ-pores are scattered instead of forming an equatorial band.

Uredospores taken from young wheat plants in the winter months (June–August) readily germinated in a moist chamber.

(Plate I., Figs. 3, 6, 10; Plate XL., Fig. 302; Plate A., Figs. 1, 2.)

CYPERACEAE.

*Carex, Urtica.*55. *Puccinia caricis* (Schum.) Rebent.

Rebentisch, Fl. Neom., p. 356 (1804).

Sydow, Mon. Ured. I., p. 648 (1903).

Sacc. Syll. VII., p. 626 (1888).

Aecidium urticae DC. Fl. franc. II., p. 243 (1805).

O. Spermogonia in small or large groups, honey coloured.

Spermatia hyaline, ellipsoid, $4\frac{1}{2} \times 2 \mu$.

I. Aecidia in rows or groups on yellowish or reddish spots, closely crowded, reaching 1 mm. in diam.; pseudoperidia cup-shaped, becoming wide at the mouth and campanulate, flattened or outstanding, with whitish margin which is toothed and reflexed.

Aecidiospores orange, polygonal to subglobose, finely echinulate, $16-26 \times 12-20 \mu$.

II. Uredosori elliptical or oblong, minute, hypophyllous, scattered or subgregarious, often confluent in long lines, erumpent, girt by the ruptured epidermis, ferruginous.

Uredospores ellipsoid or ovoid, yellowish brown, echinulate $1-2$ germ-pores on one face, $25-30 \times 19-24 \mu$.

III. Teleutosori minute, dark-brown or black, round to elliptic, scattered or gregarious, sometimes confluent, compact.

Teleutospores clavate to elongated oblong, dark-brown, smooth, constricted at septum, apex much thickened (up to 12μ) and rounded or bluntly pointed, lower cell generally attenuated towards base, $35-64 \times 16-22 \mu$, average $52 \times 22 \mu$; pedicels tinted, persistent, generally short, up to $30-40 \mu$ long.X. Mesospores not common, elongated elliptical, coloured like teleutospores, thickened and bluntly pointed at apex, $35-44 \times 12-16 \mu$.Aecidia on leaves, leaf stalks and stems of *Urtica dioica* L.

Victoria.—Bacchus Marsh, Myrniong, Fern Tree Gully, etc.

Uredo and teleutospores on leaves of *Carex breviculmis* R. Br.

Victoria—Killara, Sept., 1902 (Robinson.)

On *Carex pedunculata* Muhl.

Tasmania—Cascades, May, 1892, II., III. (Rodway).

On *Carex gunniana* Boott., and *C. inversa*, R. Br.

Tasmania—Longley, Dec., 1894, II. (Rodway).

On *Carex alsophila* F.v.M.

Victoria—Murrumbidgee Ranges, Dec., 1903, II. (Robinson)

On *Carex paniculata* L.

Victoria—Gembrook Ranges, March, 1904, II., III. (C. French, jun.)

Dr. P. Hennings has recorded a new species, *Uredo breviculmis*, on *Carex breviculmis* var. *leucochlora* Bunge, from Japan, and seeing that the host plant is a native of Japan as well as of Australia, I forwarded some of this material to him, and he replied that he scarcely thinks the two species are identical.

Magnus first experimentally proved, in 1872, that *Aecidium urticae* DC., was genetically connected with *Puccinia caricis* occurring on *Carex hirta*. Dr. Plowright also, in many cultures, has shown that the aecidiospores produce the uredospores on species of *Carex*, and the teleutospores produce the aecidiospores on *Urtica*.

On the under surface of the leaves the aecidia occur in small groups, but on the leaf-stalks and stems they are in large, bright-orange patches, thickening and distorting the parts on which they occur.

Magnus¹ has also shown that this rust winters on *Carex hirta* by means of the uredo-generation.

(Plate IV., Figs. 29, 30.)

Cyperus.

56. *Puccinia cyperi* Arthur.

Arthur, Bot. Gaz., p. 226 (1891).

Sydow, Mon. Ured. I., p. 681 (1903).

Sacc. Syll. XI., p. 199 (1895).

- II. Uredosori hypophyllous, on brown effused spots, scattered irregularly or aggregated, ellipsoid to oblong, variable in size, 1–2 mm. long, long covered by the thick epidermis, ochraceous or brownish.

Uredospores yellowish-brown, ellipsoid, echinulate, $22\text{--}25 \times 19\text{--}21 \mu$.

- III. Teleutosori hypophyllous, on similar spots, 1–3 mm. long, almost always covered by the epidermis, blackish brown.

Teleutospores intermixed with uredospores, elongated oblong to elongated fusiform, brown and paler beneath, smooth, constricted or hardly constricted at septum, $35\text{--}57 \times 15\text{--}20 \mu$, average $48 \times 15 \mu$; upper cell rounded or often obtusely and obliquely acuminate at apex, and thickened (up to 13μ); lower cell paler, oblong, but usually attenuated towards base; pedicel coloured like lower cell, persistent, $20\text{--}30 \mu$ long, but may reach a length of 40μ .

- X. Mesospores generally paler in colour than the teleutospores, ellipsoid to fusiform or even curved, obtusely and sometimes obliquely pointed at apex, thickened (up to 5μ), $30\text{--}32 \times 13\text{--}17 \mu$; pedicels similarly coloured, persistent, up to 22μ long.

On leaves of Nut grass (*Cyperus rotundus* L.).

Queensland—Gatton, Aug., 1903 (Shelton) (Bailey, ¹⁸, ²⁰).

The teleutospores are very variable in shape, and sometimes the cells may be placed almost at right angles to each other. They are sometimes excessively elongated, and may reach a length of 67μ .

Intermixed with the teleutospores there are numerous stalked bodies similarly coloured, and representing what are usually called mesospores, although Sydow describes them as paraphyses. While mesospores generally have an undoubted resemblance to the teleutospores with which they are associated, their function in this case seems to be that of paraphyses, and it may be in some other cases as well.

Darlucua filum Cast., was common on uredosori.

(Plate IV., Fig. 32.)

57. *Puccinia longispora* McAlp.

- II. Uredo-sori hypophyllous, minute, elliptic to elongated, confluent in long lines, long covered by epidermis, rusty-brown.

Uredospores sub-globose to shortly elliptic or obovate, yellowish-brown, thick-walled, echinulate, with three equatorial germ-pores on one face, $22-30 \times 19-22 \mu$, or $23-27 \mu$ diam.

- III. Teleutosori black, compact, elongated, bullate, crowded, confluent in long black lines, covered for some time, then girt by ruptured epidermis.

Teleutospores clear yellowish-brown to smoky-brown, elongated, narrow, smooth, constricted at septum, $50-80 \times 14-19 \mu$, average $63 \times 19 \mu$; upper cell darker than lower, generally rounded and slightly expanded at apex, sometimes bluntly pointed, much thickened ($9-12 \mu$); lower cell longer than upper, almost cylindrical or slightly attenuated towards base; pedicel yellow, short and often stout.

On *Carex caespitosa* L., and *C. vulgaris* Fr.

Victoria—Werribee Gorge, January, 1903. Gembrook Ranges, April, 1904 (C. French, jun.)

On *Carex* sp.

Victoria—Killara, March, 1903 (Robinson).

In immature forms of teleutospore the upper and lower cells are much alike, but ultimately the lower cell is much elongated and nearly equally broad throughout. Although 33 different Puccinias are recorded on species of *Carex*, the elongated narrow teleutospore with short pedicel is quite characteristic for this species. In *P. schoeleriana* Plow. and Mag., the teleutospores may be equally long, but the lower cell is more cuneiform than cylindrical, and the pedicel may reach a length of 57μ . An examination of teleutospores from *Carex arenaria* L. in Syd. Ured. Exs., No. 282, showed these differences distinctly.

Specimens of *P. caricis* (Schum.) Rebent. were examined from Exsicc. Sydow Ured. No. 1065 and Exsicc. Briosi and Cavara, No. 129, and the teleutospores were decidedly different.

The lower cell in *P. longispora* is much more elongated and narrower and gradually merges into the short, stout and coloured pedicel, while in *P. caricis* besides being generally considerably shorter, more wedge-shaped and somewhat inflated, the pedicel was much narrower. It is in the upper cell, however, that the difference is most striking. In *P. caricis* the thickened apex is one-half the length of the cell, while in *P. longispora* it is only one-third, taking the average of a number. The thickened apex, also, in *P. caricis* is much darker than in *P. longispora*. Of course, as in so many other cases where there are a number of species on the same genus of host-plant, there is a family resemblance too, between the rusts, and *P. caricis* and *P. longispora* have many points in common along with differences in detail.

JUNCACEAE.

Juncus.58. *Puccinia juncophila* Cooke and Mass.

Cooke and Massee, Grev. XXII., p. 37 (1893).

Sydow, Mon. Ured. I., p. 644 (1903).

Sacc. Syll. XI., p. 199 (1895).

Uredo armillata Ludwig, Bot. Centrbl. XLIII. p. 8 (1890).

- II. Uredosori ruddy-brown, ellipsoid, crowded, confluent, often girdling stem, surrounded by the ruptured epidermis and sparingly covered by shreds of it.

Uredospores sub-globose, elliptic or piriform, very spinulose, relatively thick-walled (3–4 μ) yellowish-brown, 24–32 \times 16–22 μ .

- III. Teliosori dark-brown, elliptic to oblong, surrounded by ruptured epidermis, confluent.

Teleutospores intermixed with uredospores, elliptical to oblong, golden-brown, with finely granular contents, slightly constricted at septum, rounded and a little thicker at apex (5–6 μ), lower cell rounded at base and generally resembling upper, but often somewhat narrower, 30–40 \times 20–28 μ , average 36 \times 25 μ ; epispore thick, smooth; pedicel hyaline, generally deciduous, often attached obliquely, up to 54 μ long.

- X. Mesospores similarly coloured to teleutospores, shortly elliptical, occasionally globose, smooth, thickened at apex, 23–28 \times 19–21 μ .

On *Juncus effusus* L., *J. maritimus* Lam., *J. pallidus* R. Br., *J. pauciflora* R. Br., and other species.

Victoria—Coromby, Oct., 1889, II. (Tepper), the original of *Uredo armillata* Ludw. Dimboola, Nov., 1891, II., III. (Reader). Oakleigh, April, 1893, II., III. (Morrison). Ardmona, Christmas Hills, Killara, Millbrook, Minyip, Mordialloc, Myrniong, near Melbourne, Phillip Island, Stawell, Werribee Gorge, Murramurrangbong Ranges, &c.

Tasmania—(Rodway¹).

In the original description of this species by Cooke and Massee, some mistake must have been made in the measurement of the uredospores, since they are given as 16–18 \times 12–14 μ .

Through the kindness of Dr. Morrison, I have also been able to examine some of the original material from Oakleigh.

Uredo armillata was the name given at first by Ludwig in 1889, from the uredospores only being found on *Juncus pallidus*, but the subsequent discovery of teleutospores intermixed with uredospores showed that it was a *Puccinia*. Material sent by Reader to Kew Herbarium was originally referred to *Uromyces junci* by the authorities there, but the identical specimens being later forwarded to us the two-celled teleutospores were found mixed with the uredospores. *Uromyces junci*, therefore, has not been shown to exist in Victoria.

Darluca filum Cast., was very common, in some cases rendering the patches quite black. It occurred both on uredo and teleutosori.

Luzula.59. *Puccinia tenuispora* McAlp.

- II. Uredosori hypophyllous, round to ellipsoid, scattered or often confluent in lines, yellowish-brown, soon naked and girt by the ruptured epidermis, compact, on irregular, confluent, purplish spots.

Uredospores yellowish to pale yellowish-brown, elliptical to obovate, echinulate, with 1-2 germ-pores on one face, $20-25 \times 15-22 \mu$.

- III. Teleutosori dark-brown, ellipsoid, scattered or crowded, often confluent, pulvinate, compact, soon naked, on similar spots.

Teleutospores oblong to clavate, ochrey-yellow, fragile, smooth, apex generally rounded, rarely truncate or conical, thickened up to 11μ , attenuated towards base or rounded, constricted at septum, $30-50 \times 14-20 \mu$, average, $42 \times 17 \mu$; pedicel hyaline, persistent, generally about 30μ long.

- X. Mesospores abundant, clavate to obovate or oblong, smooth, thickened at apex and similarly coloured to teleutospore, $22-32 \times 13-16 \mu$.

On leaves and stems of *Luzula campestris* L.

Victoria—Murramurrangbong Ranges, Nov. and Dec., 1902-3, Jan., 1905 (Robinson). Wandin, Nov., 1903 (C. French, jun.)

On *Luzula oldfieldii* Hook. f.

Tasmania—Mt. Wellington, Jan., 1892, II. (Rodway).

Cooke in his *Handbook of Australian Fungi* gives *Aecidium bellidis* Thuem. which is supposed to represent the aecidial stage of *Puccinia obscura* Schroet., occurring on *Luzula*, but the aecidium found on *Bellis perennis* here is associated with its own teleutospores, and belongs to a distinct fungus, *P. distincta* McAlp, so that whatever may be the case in Britain, the rust on the daisy is autoecious with us.

The discovery of a rust on *Luzula campestris*, which does not belong to the Old World species, is a further proof against its genetic connexion with that of the daisy. The species differs from *P. obscura* and *P. oblongata*. The teleutospores are characteristically fragile, thin-walled, and easily collapsible, and while of the same general type as in *P. oblongata*, they are much smaller. In *P. obscura* the colour is much deeper, and the wall is decidedly thicker and firmer. This is well shown in Plate IV., Fig. 34, in which the spores are taken from a specimen of *Luzula campestris* in Sydow's Ured. Exs., 1076, collected in 1896, and the material from which our descriptions are made is as recent as 1905. In *P. oblongata* the apex of the teleutospore is much thicker, being $10-20 \mu$, and the size is $40-80 \times 16-24 \mu$.

The teleutospores are frequently found germinating, showing that they do not require to undergo a period of rest.

Dartuca filum Cast. occurs frequently on the uredosori.

(Plate IV., Figs. 33, 34.)

LILIACEAE.

*Burchardia*60. *Puccinia burchardiae* Sacc.

Saccardo, Hedw. XXXII., p. 57 (1893).

Ludwig, Zeitsch. f. Pflanzenkr. III., p. 137 (1893).

McAlpine, Proc. Roy. Soc. Vic. VII., N.S., p. 215 (1894).

Sydow, Mon. Ured. I., p. 620 (1903).

Sacc. Syll. XI., p. 197 (1895).

- II. Uredosori amphigenous, bullate, elliptical or sometimes circular, crowded, light-brown, erumpent, surrounded at base by dry cuticle of epidermis.

Uredospores elliptic to subglobose, yellowish-brown, episporic echinulate, $28-31 \times 22-25 \mu$.

- III. Teleutosori amphigenous, numerous, small or large, erumpent, surrounded at base by cuticle of epidermis, circular or elliptical, black.

Teleutospores clavate, constricted at septum, thickened at apex (up to 14 or 15μ) and rounded, sometimes truncate or acute, $40-60 \times 14-23 \mu$, average $48 \times 20 \mu$, but sometimes attaining a length of 70μ ; lower cell tapering towards pedicel, yellowish-brown; upper cell elliptical or rarely spherical, chestnut-brown, $21-23 \mu$ broad; episporic smooth; pedicel hyaline, $30-60 \times 5-6 \mu$.

- X. Mesospores fairly common, similarly coloured to teleutospores or paler, clavate to ovate, rounded or pointed at apex and thickened, $37-43 \times 12-15 \mu$.

On stems and leaves of *Burchardia umbellata* R. Br.

Victoria—Dandenong Creek, Oct., 1891. (C. French, jun.). Near Melbourne, Sept.—Feb. Myrniong, Sept., 1898, and Dec., 1903. Murrumbidgee Ranges, Dec., 1903 (Robinson).

S. Australia—Teatree Gully, Oct., 1890 (Tepper).

The first record of this species appeared in Hedwigia of March and April, 1893, where Saccardo described it as differing from the type *P. metanarthecii* Pat.

(Plate V., Figs. 38, 39.)

Wurmbea.61. *Puccinia wurmbeae* Cooke and Mass.

Cooke and Massee, Grev. XVI., p. 74 (1887).

Cooke, Handb. Austr. Fung., p. 337 (1892).

Sydow, Mon. Ured. I., p. 640 (1903).

Sacc. Syll. VII., p. 664 (1888).

Sori elongated, bullate, dark-brown.

- II. Uredospores elliptic, granulate, brown, $25-28 \times 15-18 \mu$.

- III. Teleutospores clavate, slightly constricted at septum, smooth, upper cell convex or truncate, at apex darker, lower cell triangular, attenuated downwards into the short, hyaline pedicels, $48-60 \times 21-28 \mu$, average $50 \times 24 \mu$ (according to Cooke and Massee, $60-70 \times 20-25 \mu$); pedicels persistent, generally short, but attaining a length of 52μ and a breadth of $7-8 \mu$, being broadest at the junction with the spore.

- X. Mesospores numerous, similarly coloured to teleutospores, elongated, elliptical to oblong, thickened at apex and acute, rounded or truncate, $40-49 \times 17-21 \mu$.

On leaves of *Wurmbea dioica* F. v. M.

South Australia—Beltana, 1887 (Richards).

No uredospores were found on the specimen in National Herbarium.

(Plate V., Fig. 37.)

HAEMODORACEAE.

Haemodorum.

62. *Puccinia haemodori* P. Henn.

Hennings, Hedw. XL., p. (96) (1901).

Sydow, Mon. Ured. I., p. 609 (1903).

Sacc. Syll. XVII., p. 366 (1905).

- III. Teleutosori amphigenous, round or often oblong, scattered or aggregated and then confluent, pulvinate, compact, erumpent, black, surrounded by the ruptured epidermis, 1-2 mm. long.

Teleutospores oblong to oblong clavate, obtusely rounded or apiculate at apex and strongly thickened ($8-13 \mu$), slightly constricted at septum, attenuated or rounded at base, smooth, chestnut-brown, $40-57 \times 14-20 \mu$, average $46 \times 19 \mu$; pedicel persistent, slightly brownish towards apex, $40-55 \times 5-7 \mu$.

- X. Mesospores very common, subfusoid or ovoid to subclavate, apex gibbous to apiculate, somewhat obtuse or two-horned, thickened at apex (up to 9μ), brown, $25-40 \times 12-18 \mu$; pedicel hyaline to brownish. Occasionally a more deeply coloured spore occurs, with somewhat truncated apex, $30-46 \times 5-7 \mu$.

On leaves of *Haemodorum* sp.

West Australia—Near Perth (1900).

Hennings described uredospores in his original diagnosis, but Sydow did not find them afterwards in the original material. He remarks that the teleutospores readily separate into their two constituent cells, and since the supposed uredospores agree with the upper cell of the teleutospore, they are probably the same.

No uredospores were found by me in the specimen kindly sent by Hennings.

The teleutospores are somewhat variable in shape, and occasionally the upper cell may be ellipsoid and deep chestnut, while the lower is cylindrical, much paler in colour, and two-thirds the entire length.

(Plate V., Fig. 40.)

AMARYLLIDACEAE.

Hypoxis.

63. *Puccinia hypoxidis* McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 853 (1895).

Sydow, Mon. Ured. I., p. 607 (1903).

Sacc. Syll. XIV., p. 341 (1899).

- II. Uredosori on both surfaces and margins of leaves, minute, rust-coloured, rounded or oval, bullate, gregarious or scattered, bursting through and surrounded by epidermis.

Uredospores shortly elliptical, yellowish, finely echinulate, $20-23 \times 16-18 \mu$, average $21 \times 16 \mu$.

- III. Teleutosori amphigenous, black, blister-like, largely confluent and distorting leaf, long covered by epidermis.

Teleutospores with a few uredospores intermixed, elongated clavate, chestnut-brown, slightly or not at all constricted at septum, commonly truncate and much thickened at apex, $36-54 \times 15-22 \mu$, average $42 \times 18 \mu$; upper cell squarish or oblong or club-shaped, apex very much thickened (up to 15μ), sometimes strongly beaked, generally shorter than lower cell, dark chestnut-brown; lower cell tapering towards base, lighter in colour than upper, of a yellowish or golden brown; pedicel pale yellow, persistent, generally about $18-20 \mu$ long.

- X. Mesospores chestnut to pallid, rounded or beaked at apex and thickened, somewhat fusiform to elongated elliptical, $25-36 \times 11-18 \mu$.

On leaves of *Hypoxis glabella* R. Br.

Victoria—Ardmona, July, 1893 (Robinson). Burnley, Rutherglen, &c., July–Oct.

It differs from *P. burchardiae* Sacc. in the much smaller uredospores, and decidedly in the teleutospores, which in the latter are generally rounded at the apex or beaked, and distinctly constricted at the septum.

(Plate V., Fig. 41.)

LABIATAE.

Mentha.

64. *Puccinia menthae* Pers.

Persoon, Syn., p. 227 (1801).

Sydow, Mon. Ured. I., p. 282 (1902).

Sacc. Syll. VII., p. 617 (1888).

- [O. Spermogonia either arranged in small groups or scattered, honey-coloured.]

- [I. Aecidia hypophyllous, or frequently on stems which are much swollen, more rarely on purplish-red spots on leaves, seldom scattered; pseudoperidia immersed, flat, opening irregularly and margin scarcely or irregularly torn.

Aecidiospores subglobose, ellipsoid or polygonal, coarsely granular, pale yellowish, $24-40 \times 17-28 \mu$.]

- II. Uredosori hypophyllous, small, seated on pale spots, roundish or elliptical, scattered or aggregated, soon pulverulent and confluent, girt by the ruptured epidermis, cinnamon-brown.

Uredospores subglobose, ellipsoid or obovate, echinulate, pale-brown, generally three equatorial pores, $20-30 \times 16-19 \mu$.

- III. Teleutosori similar, but blackish-brown in colour.

Teleutospores at first intermixed with uredospores, ellipsoid to ovate, rounded at both ends, apical papilla pale or hyaline, broadly expanded, hardly constricted at septum, finely warted, golden to chestnut-brown, $24-32 \times 19-22 \mu$, but commonly $24-25 \times 19-20 \mu$; pedicel hyaline, slender, generally surpassing length of spore, up to 40μ .

X. Mesospores, occasional, similarly coloured, nearly globose, very slightly roughened, $20\ \mu$ diam.

On leaves of *Mentha laxiflora* Benth.

Victoria—near Melton (Reader).

On leaves of *Mentha pulegium* L.

Victoria—Myrniong, Aug., 1904, II., III. (Brittlebank).

The teleutospores are prominently warted.

(Plate XXIX., Fig. 250.)

ACANTHACEAE.

Ruellia.

65. *Puccinia mussoni* McAlp.

Sori amphigenous, minute, usually rounded, bullate, scattered or sometimes in groups.

II. Uredospores yellow with thick, chestnut wall, globose to shortly ellipsoid, strongly echinulate, with two germ-pores on one face, $30\text{--}38\ \mu$ diam., or $28\text{--}34 \times 18\text{--}23\ \mu$.

III. Teleutospores intermixed with uredospores, dark chestnut-brown, oblong, with thickened wall and roughened surface, sometimes slightly constricted, rounded at both ends, not thickened at apex, $36\text{--}46 \times 28\text{--}36\ \mu$; upper cell resembling lower, but usually a little larger; pedicel generally lateral and even sometimes on a level with the septum, flexuous, hyaline, up to $60\ \mu$ long and $7\ \mu$ broad.

On living leaves of *Ruellia australis* Cav.

New South Wales—Richmond River, June, 1896 (Musson).

The teleutospores were not very plentiful in the specimens examined, but the sori containing them could be detected by their darker brown colour. The lateral pedicel to the teleutospore naturally suggests *P. lateripes* B. and Rav., but a closer inspection reveals important differences in the two kinds of spores.

I have compared the Australian species with specimens on the leaves of *R. strepens* L. from N. America in Sydow's Ured. Exs., No. 1374, and Kellerman's Ohio Fungi, No. 130, and it is evident that we are dealing with similarity of type due to the affinity of the host-plants, with considerable divergence in the character of the spores. Unfortunately, *P. lateripes* B. and Rav. and *P. ruelliae* (B. and Br.) Lagh. are confounded, for although Sydow labels his specimen as the former, in his Monograph he names it the latter. In this specimen the finely echinulate uredospores are ellipsoid to ovate, and measure $24\text{--}28 \times 19\text{--}21\ \mu$, while here they are larger. The teleutospores likewise only measure $29\text{--}34 \times 18\text{--}22\ \mu$, and are very strongly warted.

This species differs from *P. longiana* Syd., in the larger uredospores and the teleutospores not being thickened at apex, and from *P. lateripes* and *P. ruelliae* in the larger size of uredo- and teleuto-spores.

(Plate V., Figs. 43, 44.)

CONVOLVULACEAE.

. *Dichondra*.66. *Puccinia dichondrae* Mont.

Montagne in Gray's Fl. Chil. VIII., p. 46 (1845).

Cooke, Handb. Austr. Fung., p. 338 (1892).

Sydow, Mon. Ured. I., p. 321 (1902), and p. 881 (1904).

Sacc. Syll. VII., p. 717 (1888).

P. dichondrae Berk. Linn. Journ. XIII., p. 173 (1872).*P. berkeleyana* De Toni, Sacc. Syll. VII., p. 717 (1888).*P. munita* Ludwig, Zeitsch. f. Pflanzenk. II., p. 133 (1892).

- III. Teleutospores hypophyllous, punctiform, very minute, erumpent to superficial, somewhat pulverulent, densely gregarious and often covering entire surface, deep cinnamon, nestling among hairs, 70–100 μ diam.

Teleutospores clavate to oblong, golden brown, constricted at septum, with comparatively thin epispore, thickened at apex and produced into a hyaline apiculus (occasionally two), with granular contents, and each cell 1-guttulate, occasionally 3 to 4 celled, 30–40 \times 12–18 μ , average 32 \times 14 μ ; pedicel hyaline, sometimes tinted, persistent, generally slender, up to 46 μ long, occasionally 6 μ broad.

- X. Mesospores sub-ellipsoid to oblong, similarly coloured to teleutospore, thickened at apex and usually with hyaline apiculus, 21–30 \times 15–22 μ .

On *Dichondra repens* Forst.

Victoria—Near Melbourne, 1886 (Reader). Cheltenham, Nov. 1887 (French). Goulburn River Flats, Oct., 1896 (Robinson). Christmas Hills, May, 1900 (Robinson). Point Cook May, 1902 (French, jun.). Murrumbidgee Ranges, Nov. 1902 (Robinson). Mt. Blackwood, Dec., 1902. Port Fairy, Aug., 1905. Mentone, throughout the year, 1905, etc.

New South Wales—1901 (Camfield). Richmond, April, 1905 (Musson). Recorded by Maiden¹.

South Australia—Mount Lofty, near Adelaide, Oct., 1891 (Tepper).

Tasmania—North East (Mueller).

I have examined the original material from the National Herbarium, Melbourne, and find that there must have been some mistake over the measurements of the spores, which were given as .005 inch (130 μ) by Berkeley, which is evidently a misprint. Next, Dr. Cooke in his *Handbook of Australian Fungi* makes a correction by giving the size of the spores as 12–13 μ long, which evidently errs on the other side. Then De Toni changed the name to *P. berkeleyana*, seeing that the size of the spores as given did not at all agree with those of *P. dichondrae*, Mont.

Another unfortunate error has arisen in connexion with this species through the wrong naming of the host-plant. Mr. Tepper sent a rust to Prof. Ludwig from S. Australia, said to be on the living leaves of *Hydrocotyle hirta* R. Br., who determined it as a new species, *P. munita*. But on Prof. Ludwig kindly sending me some of the original material it was found that the leaves belonged to *Dichondra repens* and that the rust was *P. dichondrae*, a conclusion with which Prof. Ludwig agreed after examining the specimens sent to him.

The teleutospores are frequently 3-4 celled, and there is great variety in the arrangement of the septa. The spore may be divided vertically as in *Diorchidium*, or it may have a vertical or oblique septum in its upper or lower cell. The septa may even be arranged muriformly. There may be a lateral hyaline apiculus in the lower as well as in the upper cell, and the pedicel may stand out at right angles to the lower cell.

There is thus every gradation from the unicellular spore and the bicellular, in which the upper cell is more or less atrophied, up to the multicellular, which is vertically, obliquely or muriformly divided.

Aecidia have been found on this plant and are regarded as belonging to this species, but although numerous specimens have been examined from various localities no trace of aecidiospores has been found here.

It is worthy of note that some of our native species of *Viola* closely resemble the *Dichondra*, and the one may easily be mistaken for the other when no flowers are present.

(Plate V., Fig. 42; Plate XL, Fig. 299.)

APOCYNACEAE.

Alyxia.

67. *Puccinia alyxiae* Cooke and Mass.

Cooke and Massee, Grev. XVI., p. 2 (1887).

Cooke, Handb. Austr. Fung., p. 338 (1892).

Sydow, Mon. Ured. I., p. 336 (1902).

Sacc. Syll. VII., p. 714 (1888).

- III. Teleutosori generally hypophyllous, occasionally epiphyllous, discoid, compact, dark-brown, girt by the ruptured epidermis, 1-2mm. diam.

Teleutospores almost pear-shaped or oblong, yellowish to brownish, constricted in the middle, thickened at apex and generally apiculate, sometimes rounded or truncate, occasionally 3-celled, $40-52 \times 20-25 \mu$, average $45 \times 20 \mu$; episore thick, smooth, coloured; pedicels persistent, hyaline, broadish, elongated, up to 130μ , occasionally at right angles to the spore.

- X. Mesospores not uncommon, similarly coloured, elongated oblong, thickened and sometimes apiculate at apex, $38-50 \times 19-21 \mu$.

On leaves of *Alyxia buxifolia* R. Br.

Victoria—Brighton and Broadford, Sept., 1887 (Miss Campbell!).

Beaumaris, March, 1895. Cheltenham, May, 1902 (C. French, jun.) Sandringham, April, 1905. (Robinson).

South Australia—Gawler, Sept., 1893. (Tepper).

Tasmania—Near George's Bay, Nov., 1892. (Rodway!).

The sori are generally isolated, much inflated and surrounded by a conspicuous, brown, elevated ridge. When on both surfaces they are opposite to each other.

In the Cheltenham material, the spores had germinated on the leaves lying on the ground on 19th May, while the spores on the Gawler material found in September had not.

This spore probably undergoes a period of rest during the summer before germination. Cooke and Massee have given the length of the spores as $50-70 \mu$, but this is evidently a misprint.

(Plate VI., Fig. 46.)

68. *Puccinia carissae* Cooke and Mass.

Cooke and Massee, Grev. XXII., p. 37 (1893).

Sydow, Mon. Ured. I., p. 336 (1902).

Sacc. Syll. XI., p. 195 (1895).

- III. Teleutosori hypophyllous, gregarious, on orbicular spots, forming rings which are at length confluent, rather compact, dark-brown.

Teleutospores elliptic, constricted at septum, rounded at ends or occasionally flattened, smooth, brown, $30-34 \times 17-25 \mu$, average $32 \times 22 \mu$; occasionally 3-celled, then reaching to a length of 49μ ; pedicel hyaline, deciduous or persistent, sometimes originating laterally, rather long.

- X. Mesospores occasional, just resembling a teleutospore, but without the septum, elliptic, with hyaline pedicel, $29-31 \times 22-25 \mu$.

On living leaves of *Carissa ovata* R. Br.

Queensland—Gladfield, (Gwyther) (Bailey ¹³). Dalby, (Bancroft) (Bailey ¹⁶).

Mr. Bailey has kindly sent me some excellent material from his herbarium and the teleutospores have been carefully measured. In the original description the size is given as $20-22 \times 16 \mu$, but probably $30-32 \mu$ was intended for the length.

Sometimes both upper and lower cell have an oblique division.

It differs from *P. alyxiae* Cooke and Mass., in which the spores are much larger and thickened at the apex.

(Plate VI., Fig. 45.)

GOODENIACEAE.

69. *Puccinia brunoniae* McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 851 (1895).

Sydow, Mon. Ured. I., p. 193 (1902).

Sacc. Syll. XIV., p. 320 (1899).

- O. Spermogonia dark honey-coloured, disposed in clusters on yellowish spots, or intermixed with aecidia on the same surface of the leaf, usually the upper.
- I. Aecidia scattered or more often circularly arranged on reddish, slightly swollen indeterminate spots, mostly on upper surface of leaves and on petioles; pseudoperidia with white margin, torn, slightly recurved and soon falling away, average $\frac{1}{3}$ mm. diam.; isolated peridial cells, generally short and stout, less commonly elongated oblong, punctate, with striated margin, generally $24-31 \times 14-17 \mu$, or when elongated $38-45 \times 21-24 \mu$.

Aecidiospores subglobose or angular, or even oval, deep orange, smooth, $17-21 \mu$ diam. or $18-21 \times 15-16 \mu$, occasionally as long as 24μ .

- III. Teleutosori amphigenous, but mostly on upper surface, very rarely mixed with aecidia, forming clusters of black, bullate pustules on indefinite, pale, ruddy, thin spots, oval or elongated, usually confluent, arranged circularly, or in lines, at first girt by ruptured epidermis, which finally falls away.

Teleutospores clavate, golden-brown to chestnut, thickened at apex, constricted at septum, sometimes 3 or 4 celled, $45-60 \times 18-21 \mu$, average $50 \times 20 \mu$; upper cell generally pointed, but often rounded and occasionally truncate, deeper in colour than lower; lower cell tapering towards base and generally longer than upper; pedicels persistent, pale-yellowish to hyaline, $40-50 \times 9-10 \mu$.

- X. Mesospores occasional, similarly coloured to teleutospores, rather oblong, thickened at apex, rounded or truncate, slightly narrowed at base, $28-38 \times 17-21 \mu$.

On leaves and petioles of *Brunonia australis* Sm.

Victoria—Drysdale, Oct., 1895, III. Murramurrangbong Ranges. Nov., 1902, Dec., 1903, O., I., III., and Jan., 1905, III, (Robinson). Alps, near Bright, Dec., 1904, III. (C. French, jun.). Rutherglen, Dec., 1904, III.

Three-celled teleutospores occasionally seen, varying in length from $60-73 \mu$ and in breadth from $21-24 \mu$, the lower cell generally about as long as the other two.

Four-celled teleutospores are very rare, elongated clavate, $63 \times 24 \mu$, the two upper cells about $33 \times 24 \mu$, and the two lower $30 \times 14 \mu$. In the same group there were three 3-celled teleutospores with an average size of $59 \times 23 \mu$.

At first no aecidia were known, but these were found along with the teleutospores by G. H. Robinson.

The discovery of aecidia rendered it necessary to carefully compare the two fungi found upon the Goodeniaceous plants, *Brunonia* and *Goodenia*, and a large number of specimens and slides were accordingly examined and compared.

While the rusts are of the same general type, they differ in several important respects. The aecidiospores in *P. saccardoi* are considerably smaller, and the peridial cells are generally much more elongated, and more than twice as long as broad.

In the original description by Dr. Ludwig the size of the aecidiospores is given as $13-15 \mu$ diam., and the peridial cells as $18-25 \times 15-18 \mu$, but if the latter are measured when isolated they are found to be much longer. Again in *P. saccardoi* the teleutospores are generally intermixed with or surround the aecidia, but this very rarely occurs in *P. brunoniae*. In the former the teleutospores are generally rounded at apex, but in the latter generally pointed and altogether narrower.

In the Murramurrangbong Ranges where the aecidia and teleutospores of *P. brunoniae* were found very plentifully in November, though Goodeniaceous plants which, in other districts are affected by *P. saccardoi*, were exceedingly common and were often growing alongside the *Brunonia*, no rusts were found on them, even although the country was subjected to a most exhaustive search. The rusts, therefore, on the two different genera are considered to be specifically distinct.

70. *Puccinia dampierae* Syd.

Sydow, Mon. Ured. I., p. 193 (1902).

Sacc. Syll. XVII., p. 315 (1905).

- I. Aecidia on stems and both surfaces of leaf, gregarious, bright orange; pseudoperidia with white reflexed and torn margins, $\frac{1}{3}$ – $\frac{1}{2}$ mm. in diam.; peridial cells lozenge-shaped to oblong, with thick striated margins, 30–40 μ long.

Aecidiospores orange, subglobose, ellipsoid to oblong, finely echinulate, 15–17 μ diam. or 17–19 \times 13–14 μ .

- III. Teleutosori on stems, scattered or aggregated, round or oblong, about 1 mm. diam., compact, dark-brown, girt by the ruptured epidermis.

Teleutospores clavate, rounded or acute at apex and strongly thickened (8–11 μ), constricted at septum, attenuated downwards, rarely round, smooth, brown, 48–66 \times 16–26 μ ; pedicel yellowish, persistent, up to 80 μ long.

- X. Mesospores intermixed with teleutospores, clavate, 40–55 \times 14–22 μ .

On stem and leaves of *Dampiera stricta* R. Br.

Victoria—Monbulk, Dec., 1905, I. (C. French, jr.).

On wings of the stems of *Dampiera alata* Lindl.

West Australia, III. (L. Preiss).

Though I have not seen the West Australian specimens I prefer to regard the aecidia found in Victoria as a stage of the same fungus. If they should prove to be unrelated they would be easily separable at any time.

Leschenaultia.

71. *Puccinia gilgiana* P. Henn.

Hennings, Hedw. XL., p. (95) (1901).

Sydow, Mon. Ured. I., p. 194 (1902).

Sacc. Syll. XVII., p. 314 (1905).

Aecidium perkinsiae P. Henn. Hedw., XL., p. (96) (1901).

- I. Aecidia on thickened and slightly deformed parts, gregarious or scattered; pseudoperidia hemispherical to cup-shaped, semi-immersed, yellowish to ruddy; peridial cells round or oblong-polygonal, subhyaline, reticulate, 18–24 \times 16–20 μ .

Aecidiospores subglobose or ellipsoid, angular, finely echinulate, yellowish, 15–20 μ diam.

- II. Uredosori on stems, gregarious in streaks, oblong, surrounded or almost covered by the ruptured brown epidermis, somewhat pulverulent.

Uredospores subglobose, ovoid or ellipsoid, yellowish to brown, echinulate, 14–21 \times 12–18 μ .

- III. Teleutosori similar, but black.

Teleutospores clavate or oblong, constricted at septum, smooth, obtusely rounded or truncate at apex and slightly thickened (up to 5 μ), obliquely papillate and occasionally crested, rounded at base or attenuated, brown, 30–45 \times 16–22 μ , average 42 \times 20 μ ; pedicel brownish, thick, persistent, 30–50 μ long.

- X. Mesospores very common, oblong or oblong-clavate, thickened at apex, rounded or acute, chestnut-brown, smooth, stalked, $23\text{--}32 \times 15\text{--}20 \mu$.

On petioles, calyx and stems of *Leschenaultia linarioides* DC.

West Australia—Near Perth, 1900 (Pritzel).

Aecidia on petioles, flower-stalks, and calyx; uredo and teleutospores on stems.

Specimens kindly supplied by Hennings.

(Plate VI., Fig. 47.)

Goodenia, Velleia.

72. **Puccinia saccardoi** Ludw.

Ludwig, Hedw. XXVIII., p. 362 (1889).

Cooke, Handb. Austr. Fung., p. 337 (1892).

Sydow, Mon. Ured. I., p. 193 (1902).

Sacc. Syll. IX., p. 309 (1891).

P. nigricaulis McAlp., Agr. Gaz. N.S.W. VII., p. 151 (1896).

Aecidium goodeniacearum (in part) Berkeley, Linn. Journ. XIII., p. 173 (1872).

- I. Aecidia on yellowish or brownish spots, scattered or in groups arranged in circular patches (up to 6mm. diam.), amphigenous causing distortion of stem; pseudoperidia cup-shaped, with white torn, everted edges, $215\text{--}325 \mu$, diam.; isolated peridial cells punctate, with striated margin, generally elongated oblong, or somewhat oval or lozenge-shaped, more than twice as long as broad, $35\text{--}42 \times 16\text{--}21 \mu$.

Aecidiospores subglobose, polygonal to oval, orange, very finely verrucose, $14\text{--}16 \mu$, diam., or $15\text{--}17 \times 13\text{--}14 \mu$.

- III. Teleutospores on both surfaces of leaves and on stems, black, compact, roundish or elongated, confluent in long swollen patches, generally intermixed with or surrounding aecidia, bursting through epidermis.

Teleutospores clavate to oblong, dark-brown, constricted at septum, smooth, variable in size, rarely 3-celled, $40\text{--}66 \times 17\text{--}25 \mu$, occasionally up to 70μ long, average, $54 \times 20 \mu$; upper cell subglobose or somewhat quadrate, thickened at apex (up to 9μ), generally rounded or truncate, occasionally pointed, $21\text{--}30 \times 17\text{--}25 \mu$, sometimes reaching 32μ in length; lower cell generally paler in colour than upper, elongated and tapering towards base, sometimes subglobose, longer and narrower than upper, $17\text{--}35 \times 16\text{--}21 \mu$, occasionally 38μ long; pedicel usually persistent, hyaline, occasionally pale-yellow, $35\text{--}60 \times 7\text{--}12 \mu$.

- X. Mesospores common, similarly coloured to teleutospores or paler, variously shaped, ellipsoid to oval, or oblong to clavate, smooth, with pointed and thickened apex (up to 9μ), and generally slightly tapering towards base, $25\text{--}49 \times 12\text{--}21 \mu$, or averaging $36 \times 17 \mu$.

On stems, leaves and calyx of *Goodenia geniculata* R. Br., *G. glauca* F. v. M., *G. pinnatifida* Schlecht., *G. albiflora* Schlecht., *G. hederacea* Sm., and *G. ovata* Sm.

Victoria—Port Phillip, 1886, I. Dimboola, Sept., 1892, I., III. (Reader). Minyip, near Colac, Grampians, Warracknabeal, Nhill, Killara, Mt. St. Bernard, Borung, Gembrook, near Melbourne.

S. Australia—Tanunda Scrub, Oct., 1887 (Tepper). Mt. Brown Creek, near Quorn, Sept., 1892 (Molineux).

Tasmania—Cascades, Jan., May, Nov., 1892 and 1893, I. (Rodway¹). Devonport, Jan., 1906, I., III. (Robinson).

On *Velleia macrocalyx* De Vriese.

New South Wales—Guntawang, Sept., 1886 (Hamilton).

On *Velleia paradoxa* R. Br.

Victoria—Pine Plains, I. (Reader).

New South Wales—Guntawang, Sept., 1886, I. III. (Hamilton).

I have received from Prof. Saccardo some of the original material on *G. geniculata* from S. Australia, and on comparing it with *P. nigricaulis* McAlp., have no doubt but that they are the same. The Victorian specimens, however, occur very plentifully on the stems as well as on the leaves, and under favorable conditions the fungus obtains such profuse development as to cause blackening and distortion of the stems.

Aecidium goodeniacearum Berk. belongs partly to *P. saccardo* and to *Uromyces puccinioides*. In specimens of *Goodenia pinnatifida*, received from F. M. Reader, Dimboola, the fungus is named *A. goodeniacearum* Berk. in Massee's handwriting, while the teleutospores of *P. saccardo* are also met with intermixed with the aecidia.

In *Velleia paradoxa*, from New South Wales, while the teleutospores are of the general type, there are quite a number in which the apex is truncate and prolonged laterally into a thickened, more or less beak-like projection. But Ludwig observed in the original type on *Goodenia geniculata* a similar variety, so that the spores on the genera *Goodenia* and *Velleia* cannot be differentiated. He writes—"Mixed among the normal teleutospores there are three and one-celled spores, the latter sometimes of abnormal size, as I have observed under similar conditions in *P. heterospora*. Frequently very peculiar forms appeared, in which the upper cell bore 1-3 horn-like projections as long as the cell itself, or finger-like cells, as long as the upper, proceeded from the lower cell."

(Plate VI., Figs. 48, 49.)

CAMPANULACEAE.

Lobelia, Pratia.

73. *Puccinia aucta* Berk. and F. v. M.

Berkeley and F. von Mueller, Linn. Journ. XIII., p. 173 (1872).

Cooke, Grev. XI., p. 98 (1883).

Cooke, Handb. Austr. Fung., p. 338 (1892).

Sydow, Mon. Ured. I., p. 196 (1902).

Sacc. Syll. VII., p. 676 (1888).

Aecidium microstomum Berk. Journ. Linn. Soc. XIII, p. 173 (1872).

A. lobeliae Thuem. Grev. IV., p. 75 (1875).

- O. Spermatogonia slightly raised, with projecting paraphyses, honey coloured, in groups.

Spermatia numerous, hyaline, ellipsoid, $5\text{--}6 \times 3 \mu$.

- I. Aecidia amphigenous, rounded or ovate, scattered or densely gregarious and occupying the entire surface of the leaves or petioles, at first covered by the epidermis, then free and rupturing like a broken blister, vesicular, ochraceous; pseudoperidial cells, oval to oblong, covered with spines, loosely connected, $30\text{--}40 \times 18\text{--}25 \mu$.

Aecidiospores irregularly globose, sub-angular or ellipsoid, finely echinulate, with distinct wall, ochraceous, $18\text{--}22 \mu$ or $22\text{--}28 \times 18\text{--}20 \mu$.

- III. Teleutosori on under surface, numerous, bullate, then girt by the ruptured epidermis so that they resemble little *Pezizae*.

Teleutospores cylindric to sub-clavate, elongated, yellow, thickened apex ($9\text{--}10 \mu$), rounded or truncate, deeply constricted at septum $56\text{--}70 \times 15\text{--}26 \mu$, average 60×24 , occasionally bi- and tri-septate when they may reach a length of 80μ ; upper cell generally broader than lower; lower cell generally cylindrical, and may taper slightly towards pedicel; pedicel hyaline, short, stout, $7\text{--}13 \mu$ broad.

Aecidiospores on *Lobelia anceps* L., *L. pratoides* Benth., *L. purpurascens*

- R. Br., *Pratia erecta* Gaudich., *P. pedunculata* Benth., *P. platycalyx* Benth.

Victoria—Colac (F. v. Mueller), (von Thuemen). Murtoa, Oct., 1892, (Reader). Ringwood, Oct., 1892 (Robinson). Minyip, Oct., 1901 (Eckert). Werribee Plains, June, 1902 (C. French, jun.).

New South Wales—Guntawang, Sept., 1886 (Hamilton). Kurrajong Heights, Apr., 1894 (Mussn.).

Tasmania—Bellerive Swamp, Dec., 1891 (Rodway).

Teleutospores on leaves of *Lobelia anceps* L.

South Australia—Port Lincoln, Nov., 1852 (C. Wilhelmi), (Berkeley²).

The aecidium was first determined by Thuemen on a specimen of *Pratia platycalyx* sent by the late Baron von Mueller from Colac, and named *A. lobeliae*. Then Berkeley received a specimen from the same source on *P. pedunculata* which he named *A. microstomum*.

I have examined portions of the original material of both these specimens, and as a rule it is difficult to detect a peredial wall even in fine sections, so much so that they were as first taken for caecomata. But there is occasionally a loosely fitting layer of surrounding cells, so that we may regard them as aecidia. The aecidial stage is given in connexion with the teleuto stage since, although not found actually together, they occur separately on the same species, *Lobelia anceps*.

The teleutospore is occasionally tri-septate, and is then slightly curved, and the lower septum oblique.

The description of the teleuto stage is drawn up from original specimens in the National Herbarium, named in Berkeley's handwriting.

(Plate VI., Fig. 51; Plate XXXIX., Fig. 289.)

COMPOSITAE.

Scorzonera.

74. *Puccinia angustifoliae* McAlp.

- I. Aecidia in dense clusters on the leaves, more sparingly on stems, about $\frac{1}{3}$ to nearly $\frac{1}{2}$ mm. diam.; pseudoperidia with finely laciniate everted margins.

Aecidiospores orange-yellow, globose to elliptical or sub-quadrate, 16×11 – 13μ or 13 – 14μ diam.

- III. Teleutosori on leaf and stem, black, long covered by epidermis, confluent, forming elongated patches, partially rupturing and throwing off epidermis, distinct from or along with aecidia.

Teleutospores clavate to oblong, smoky-brown, slightly constricted at septum, smooth, generally rounded and thickened at apex (up to 9μ), slightly tapering towards base or often rounded, 40 – 53×16 – 21μ , average $50 \times 20 \mu$; pedicel hyaline, deciduous, generally short, up to 38μ long and 9μ broad.

- X. Mesospores common, similarly colored to teleutospores, or paler, generally somewhat oval, thickened at apex, 25 – 30×16 – 17μ .

On *Scorzonera angustifolia* L.

Victoria—Dimboola, Nov., 1892, I., III. (Reader).

This species differs from *P. podospermi* DC., *P. scorzonerae* (Schum.) Jacky and *P. tragopogi* (Pers.) Corda, in the absence of uredospores and the smooth teleutospores.

(Plate VII., Fig. 53.)

Brachycome.

75. *Puccinia brachycomes* McAlp.

- I. Aecidia crowded on swollen and distorted portions of leaves, also on stems and branches, about $\frac{1}{3}$ mm. diam.; pseudoperidia round, out-standing, with white, slightly everted, laciniate margin; pseudoperidial cells firmly united, oblong to sub-quadrate, punctulate all over, with broad striated margin.

Aecidiospores yellowish, sub-globose to ellipsoid, finely echinulate, 13 – 16μ diam. or 13 – 16×10 – 13μ .

- II. Teleutosori elliptical, pustulate, black to blackish-brown, long covered by epidermis, crowded, confluent, and ultimately forming elongated patches several mm. in length.

Teleutospores clavate, dark chestnut-brown, smooth, very slightly constricted at septum, 48 – 64×18 – 25μ , average $50 \times 20 \mu$; upper cell truncate or conoid, occasionally rounded at apex, thickened (up to 9μ); lower cell generally attenuated towards base, sometimes rounded and generally longer than upper; pedicels persistent, tinted or hyaline, up to 35μ long.

- X. Mesospores not uncommon, similarly coloured to teleutospores, ellipsoid, either rounded or pointed, and thickened at apex, 28 – 30×14 – 19μ .

On *Brachycome ciliaris* Less., I., III., and *B. pachyptera* Turcz., I.

Victoria—Dimboola, May–July, 1896 and 1898 (Reader).

On *Brachycome scapiformis* DC. and *B. diversifolia*, Fischer and Mey.

Victoria—Buffalo Ranges, Dec., 1904, I., III. (C. French, jun.).

Darlucium filum Cast., is a very common parasite on the aecidia.

(Plate VIII., Fig. 66.)

*Calendula.*76. *Puccinia calendulae* McAlp.

McAlpine, Proc. Linn. Soc. N.S.W. XXVIII., p. 558 (1903).

Sydow, Mon. Ured. I., p. 852 (1904).

Sacc. Syll. XVII., p. 280 (1905).

Aecidium calendulae McAlp. Agr. Gaz. N.S.W. VII., p. 152 (1896).

- I. Aecidia amphigenous or on stems, orange-yellow, in clusters up to 6 mm. diam, sometimes circinate, or may be scattered irregularly; pseudoperidia with white, torn and reflexed margin; peridial cells quadrate or polygonal, striated at margin, 21–24 μ long.

Aecidiospores very irregular, sub-globose to polygonal, very finely echinulate, pale orange, 14–17 \times 11–12 μ or 12–16 μ diam.

- III. Teleutosori intermixed with aecidia, black, erumpent, soon naked, girt by the ruptured epidermis, circular to elliptical, minute, compact, often confluent.

Teleutospores yellowish-brown, clavate to oblong clavate, constricted at septum, rounded or acute at apex and thickened (up to 12 μ), attenuated towards base, smooth, 36–52 \times 19–23 μ , average 48 \times 20 μ ; upper cell darker in colour and broader than lower, 21–31 μ long; lower cell slightly or not at all tapering towards pedicel and averaging same length as upper; pedicel persistent, hyaline, but coloured towards apex, 28–37 \times 7–8 μ , but may attain a breadth of 10 μ at junction with spore.

- X. Mesospores not uncommon, similarly coloured to teleutospores, ovate to elliptical or pear-shaped, thickened at apex, 30–42 \times 21–23 μ .

On leaves and all green parts, including fruits of *Calendula officinalis* L.

Victoria—Near Melbourne, growing in gardens, 1892, &c. Killara, July–Oct., 1902. Geelong, Nov., 1904, I., III. (Pescott). Frankston, August, 1904, I.

Aecidial stage all the year round, but less common in mid-summer, persisting only in shady gardens. Teleutostage from March to November.

The aecidial stage was the only one found at first, and was described in the *Agricultural Gazette* of New South Wales for 1896 at p. 152. Then in March, 1902, the teleutostage was found by Mr. G. H. Robinson, and was very plentiful. Both stages very common in University Gardens, Melbourne, in autumn and winter of 1905. Mesospores germinating at apex like teleutospores, and producing sporidiola.

It causes swelling, discoloration and distortion of the flower-stems and leaves, and the bright orange colour of the aecidia on the leaves at once attracts attention from its harmonising with the flower-head.

(Plates VIII., Fig. 65; XLIII., Fig. 312; Plate E., Figs. 22, 23.)

*Calocephalus.*77. *Puccinia calocephali* McAlp.

- I. Aecidia very sparse on upper surface of hairy leaves, about $\frac{1}{3}$ mm. diam.; pseudoperidia saucer-shaped, lacinate at margin; peridial cells, oblong to lozenge-shaped, striated, 25–32 μ long.

Aecidiospores sub-globose to angular, orange-yellow, smooth, showing up to 4 germ-pores on one face, $16-19 \times 12-13 \mu$ or $14-16 \mu$ diam.

- III. Teleutosori black to blackish-brown, long covered by leaden epidermis, pulvinate, compact, round to elongated, sometimes confluent, $1-1\frac{1}{2}$ mm. long.

Teleutospores clavate, dark brown, particularly in upper cell, slightly constricted at septum, smooth, $40-57 \times 17-24 \mu$, average $45 \times 22 \mu$; upper cell rounded, scoop-shaped, sometimes truncate and thickened at apex (up to 11μ); lower cell yellowish brown, attenuated towards base; pedicels persistent, tinted to hyaline, up to 35μ long and sometimes 10μ broad.

- X. Mesospores common, elongated, elliptical to oblong, generally paler than teleutospore, thickened at apex, and generally scoop-shaped, $28-35 \times 13-16 \mu$.

On leaves and stem of *Calocephalus drummondii* Benth., and *C. lacteus* Less.

Victoria—Dimboola, Sept., 1891, III. (Reader). Phillip Island, Nov., 1901, I. (C. French, jun.)

The teleutosori and teleutospores generally resemble those of *P. tasmanica* Diet., but they are not intermixed with aecidia. They both belong, however, to the same general type.

(Plate VII., Fig. 58.)

Calotis.

78. *Puccinia calotidis* McAlp.

- I. Aecidia amphigenous, in irregular clusters, orange; pseudoperidia cup-shaped, with whitish, reflexed, laciniate margins.

Aecidiospores subglobose to polygonal, finely echinulate, $13-14 \mu$ diam., or $13-15 \times 12 \mu$.

- III. Teleutosori minute, black, erumpent, gregarious, compact.

Teleutospores dark chestnut-brown, oblong to elongated oblong or clavate, smooth, constricted at septum, rounded or bluntly pointed and thickened at apex (up to 9μ), $37-50 \times 18-28 \mu$, average $38-40 \times 18-20 \mu$; pedicel hyaline, persistent, generally tapering towards base, about 30μ long, or shorter than spore.

- X. Mesospores not uncommon, similarly coloured to teleutospores, and stalked, obovoid to ellipsoid, rounded or bluntly pointed and thickened at apex ($6-8 \mu$), $28-37 \times 15-18 \mu$.

On *Calotis cuneifolia* R. Br. and *Calotis* sp.

New South Wales—Guntawang, Sept., 1886 (Hamilton).
Condoblin, Aug., 1897 (Maiden).

The teleutospores generally resemble those of *P. vittadiniae*, but they are longer on the average.

(Plate XLIII., Fig. 310.)

*Chrysanthemum.*79. *Puccinia chrysanthemi* Roze.

Roze, Bull. Soc. Myc. France, p. 92 (1900).
 Sydow, Mon. Ured. I., p. 46 (1902), p. 854 (1904).
 Sacc. Syll. XVI., p. 296 (1902).

P. chrysanthemi chinensis P. Henn. Hedw. XL., p. (26) (1901).

- II. Uredosori on both surfaces of leaf, but mostly hypophyllous, sparingly on stem, generally round, soon naked, powdery, scattered or crowded, often confluent, sometimes arranged circularly, snuff brown, average $1-1\frac{1}{2}$ mm. diam., causing dirty-brown, indefinite spots on upper surface of leaf, which gradually extend and ultimately decay.

Uredospores ellipsoid to obovoid, yellowish-brown to golden-brown, echinulate, with 3 equatorial germ-pores on one face, $28-35 \times 22-25 \mu$ (32μ long very common, occasionally reaching a length of 45μ); pedicels hyaline, rarely persistent, stout, long, up to 60μ .

- [III. Teleutosori on both surfaces of leaf, but chiefly on under surface, prominent, roundish, pulvinate, solitary or confluent in groups, often concentrically arranged, dark-brown to black, soon naked, compact.

Teleutospores at first sparingly intermixed with uredospores, ellipsoid to pear-shaped or clavate, rounded or occasionally truncate at apex, and thickened (up to 9μ), mostly rounded at base or sometimes slightly attenuated, chestnut-brown, with strong, finely punctulate epispore, $35-60 \times 19-28 \mu$; pedicel hyaline, stout, persistent, $40-80 \times 7-9 \mu$.]

- [X. Mesospores rare, ellipsoid to clavate, similarly coloured to teleutospores, rounded and thickened at apex, finely punctulate, $28-46 \times 22-25 \mu$.]

On cultivated Chrysanthemums (*Chrysanthemum indicum* L.).

New South Wales—Sydney Botanic Gardens, April, 1904 (Maiden). Sydney, May, 1904.

This species has been assigned to *P. hieracii* by Massee, but Jacky^{1,2,3} has shown, by means of infection experiments, that it confines itself to the one genus, and does not infect other Compositae. He has also experimented with the Japanese chrysanthemum rust, *P. chrysanthemi-chinensis* P. Henn., and proved it to be the same species as the other.

Through the kindness of Professor Ideta, of the Agricultural College, Osaka, Japan, I have received abundant material of the Japanese rust, both in its uredo and teleuto stages, and am thereby enabled to compare it with the rust occurring in Australia, as far as the uredo stage is concerned. The uredospores are quite similar, having three equatorial germ-pores on one face, and measuring $28-37 \times 22-25 \mu$. Jacky³ succeeded in infecting *C. indicum* L., with material from *C. sinense* Sabine, and thus showed the identity of the two rusts, although apparently in Europe and Australia it is gradually losing the capacity to form teleutospores. Indeed, Miss Gibson¹ goes so far as to say that there is no necessity for resting-spores, for the young shoots are above ground long before the old ones die away, and these young shoots are taken as cuttings, so that there is no time when there are no leaves upon which the rust can live.

The same author also records the fact that there are certain varieties of chrysanthemum which do not take the rust, although growing among plants badly rusted, but Jacky³ tested a number of different varieties and found them equally predisposed to the rust.

Our chrysanthemum growers sometimes express a fear that the rust seen on hollyhock, sunflower, and other plants may pass to the chrysanthemum when it has suddenly become temporarily weak through drought or other causes; but it ought to reassure them to know that the specific rust, known as *Puccinia chrysanthemi*, is alone capable of producing infection on that particular host.

In the European material Jacky detected what he considers to be two-celled uredospores, but Sydow regards them as two unicellular spores stuck together. It may be mentioned here to show the wonderful variety, that in the Japanese material I found two uredospores borne on the same stalk, the one slightly beneath the other.

The teleutospore is sometimes described as smooth, but by careful focusing it may be seen to be finely punctulated all over in the young stage, although in the mature and deeply-coloured spore this is difficult to see, only being visible on the thickened apex.

The mesospores were obtained from the Japanese material, and are rather rare.

This rust was probably introduced into Europe from Japan, and it may have reached Australia either from Europe or Japan. It is strange that the rust has not yet found its way into Victoria, considering the number of chrysanthemums imported from England, France, America, and Japan.

It was first observed in England in 1895, although it probably existed there before that time; in America in 1896; in France and Italy in 1897; and about 1898 it spread to Germany, then to Denmark and Switzerland, and at length it has found its way to Australia. In 1904 it was also recorded for New Zealand by Kirk.

It is found that many of the Australian-raised varieties are less liable to rust than others when grown in England or America.

(Plate XXIX., Figs. 251–255; Plate E., Fig. 21.).

Cichorium.

80. *Puccinia cichorii* (DC.) Bell.

Bell., in Kickx. Fl. Fland. II. p. 65 (1867).

Sydow, Mon. Ured. I., p. 49 (1902).

Sacc. Syll. VII., p. 606 (1888); XVII., p. 311 (1905).

- II. Uredosori amphigenous or on stem, minute, pulverulent, scattered or confluent, girt or partially covered by ruptured epidermis, cinnamon.

Uredospores globose, subglobose or ellipsoid, echinulate, yellowish-brown, with one or two germ-pores on one face, sometimes three to four, $22-29 \times 19-23 \mu$, or $22-25 \mu$ diam.

- III. Teleutosori similar, dark-brown.

Teleutospores intermixed sparingly with uredospores, ellipsoid or ovate-ellipsoid, brown to golden-brown, smooth, not or hardly constricted at septum, apex rounded not thickened, base for the most part rounded or very slightly attenuated, epispore thin, germ-pore in each cell prominent, with finely granular contents, $27-38 \times 19-25 \mu$, occasionally reaching 50μ long, but averaging $35 \times 20 \mu$; pedicel hyaline, short.

On leaves and stems of *Eichorium intybus* L.

Victoria—1885 (Mueller³) II. Near Melbourne, Aug., 1896.

Phillip Island, Jan., 1900; March, 1904.

The uredospores were common chiefly on the leaves, but the teleutospores were rather scarce, and occurred mostly on the midribs. Fischer⁵ describes the teleutospores as being finely warted, while Sydow considers them to be smooth. When the uredo and teleutospores are examined together, as they often occur in nature, the former are seen to be covered with decided prickles, which project from the margin, while the latter have fine points on the surface, which are only to be seen at the margin by careful focussing.

Although no mesospores were met with there were several cases where the upper cell of the teleutospores was colourless, shrivelled, and much reduced in size, while the lower cell was enlarged. The two cells are generally equal in length, but in one of the cases referred to the lower cell was $25\ \mu$ long, and the upper colourless one only $6\ \mu$.

Darluka filum Cast., was plentiful on the uredosori and the sori containing uredo and teleutospores intermixed.

(Plate VIII., Fig. 61; Plate D., Fig. 18.)

Cineraria.

81. *Puccinia cinerariae* McAlp.

- I. Aecidia on both surfaces of the leaf, running along veins and gregarious, causing depressions on upper surface and swelling of the veins on under surface, $\frac{1}{3}$ mm. diam.; pseudoperidia very slightly projecting, with margins white, everted, fimbriate; peridial cells roughly quadrangular, often rounded at one end, longer than broad, with radiating marginal lines, $22-26 \times 19-21\ \mu$.

Aecidiospores bright orange, subglobose to polygonal, very finely verrucose, $15-19\ \mu$ diam. or $15-17 \times 13\ \mu$.

- III. Teleutosori intermixed with aecidia, black, comparatively rare.

Teleutospores clavate, chestnut-brown, generally rounded and much thickened at apex or bluntly pointed, occasionally truncate, constricted at septum, $36-54 \times 17-24\ \mu$, average $40 \times 23\ \mu$; upper cell usually darker in colour, hemispherical, apex thickened to a depth of $9\ \mu$, $17-24\ \mu$ long; lower cell gradually tapering towards base, somewhat triangular, $18-30\ \mu$ long; pedicel persistent, tinted, up to $45\ \mu$ long.

- X. Mesospores chestnut-brown, obovate to elongated elliptical, much thickened at apex, with long pedicel, $27-36 \times 13-23\ \mu$.

On leaves of cultivated *Cineraria*.

Victoria—In nursery near Melbourne, April, 1899 (Cronin).

The following note accompanied the specimen:—The plants were grown under glass, and were generally very healthy. There are not many leaves so affected owing to the care that is taken to cut out the spots as soon as noticed. The disease spreads rapidly if neglected, and completely spoils a plant by denuding it of its foliage.

Caecoma cinerariae Rostr., was found on leaves and stems in Jutland.

(Plate VIII., Fig. 60.)

82. *Puccinia cyani* (Schleich.) Pass.

Passerini in Rabh. Fung. Eur., No. 1767.

Sydow, Mon. Ured. I., p. 38 (1902).

Sacc. Syll. VII., p. 634 (1888); XVII., p. 286 (1905).

- II. Uredosori mostly hypophyllous, scattered or crowded, minute, orbicular or elliptic, pulverulent, reddish brown.

Uredospores yellowish brown, globose, subglobose to ellipsoid finely echinulate, with two germ-pores on one face, $25-27 \times 19-24 \mu$.

- III. Teleutosori amphigenous, and on stem, scattered, pulverulent, dark-brown, orbicular to elliptic, soon naked, $\frac{1}{2}-1$ mm.

Teleutospores intermixed with uredospores, chestnut-brown, ellipsoid, rounded at both ends, unthickened at apex, not constricted at septum, delicately warted, germ-pores conspicuous, $30-40 \times 22-30 \mu$, average $32 \times 24 \mu$; epispore about 3μ thick; pedicel hyaline, short, deciduous.

On leaves and stems of *Centaurea cyanus* L.

Victoria—Near Melbourne, Jan. and Feb., 1904 (C. French, jr.).

This is evidently of the *Puccinia hieracii* type.

The teleutospores are very regular and well defined, and there is no tendency to abnormality.

(Plate VIII., Fig. 64.)

83. *Puccinia distincta* McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 853 (1895).

Sydow, Mon. Ured. I., p. 29 (1902), and p. 850 (1904).

Sacc. Syll. XIV., p. 311 (1899).

- I. Aecidia seated on discoloured spots, amphigenous, arranged in a circinate manner, or irregularly disposed, and often distributed over entire surface; pseudoperidia cup-shaped, with reflexed torn margins, about $\frac{1}{4}-\frac{1}{2}$ mm. diam.; peridial cells elongated elliptical to oblong, punctulate all over, $25-29 \times 13-19 \mu$.

Aecidiospores subglobose to oval or ellipsoid, orange-yellow, very finely echinulate, $14-19 \mu$ diam., or $14-20 \times 13-16 \mu$.

- III. Teleutosori intermixed with and often surrounding aecidia, brownish black, oval, $\frac{1}{2}-1$ mm. long, generally confluent, bursting through and surrounded by the leaden-coloured epidermis.

Teleutospores chestnut-brown, clavate or oblong clavate, attenuated at base, smooth, constricted at septum, $34-50 \times 15-21 \mu$, average $42 \times 17 \mu$; upper cell generally darker in colour than lower, rounded and thickened at apex (up to 9μ); pedicel persistent, pale yellow or coloured similarly to lower cell, up to 50μ long.

- X. Mesospores numerous, elongated clavate to somewhat ovate, chestnut brown, usually thickened at apex, $34-37 \times 13-16 \mu$.

On leaves, scapes, involucre and petals of *Bellis perennis* L.

Victoria—Near Melbourne, Oct., 1892, July-Oct., 1904, I., III. (Robinson). Korumburra, May, 1903, I.

Tasmania—Near Huon Road, Nov., 1890, I. (Rodway).

South Australia—Norwood, April, 1903, I., III. (Tepper). Port Pirie, Oct., 1903, I., III. (Dickens).

Aecidiospores abundant from April to September, and even to January. The aecidia may even occur on the petals, and they have been described before the Microscopical Society of Victoria as early as 1880.

Teleutospores in October or November, although they occur sparingly as early as April. The spots are generally pale-yellowish to pale greenish in colour. This aecidium from Victoria was determined by Cooke as *A. bellidis* Thuem., which belongs to *P. obscura* Schroet., but now that the teleutospores belonging to it have been found on the same host-plant the *Puccinia* is seen to be a distinct species.

(Plate VIII., Fig. 67 ; Plate E., Fig. 26.)

Erechtites.

84. *Puccinia erechtitis* McAlp.

McAlpine, Proc. Roy. Soc. Vic. VII., N.S., p. 216 (1894).

Sydow, Mon. Ured. I., p. 78 (1902).

Sacc. Syll. XIV., p. 309 (1899).

- O. Spermogonia on brownish patches on upper surface of leaf, in groups, brown to honey-colour, yellowish by transmitted light.

Spermatia hyaline, oval, $3\ \mu$ long.

- I. Aecidia on stem and leaves, causing distortion and swelling, pale-yellow at first, becoming orange-yellow, arranged close together in lines or irregularly ; pseudoperidia cup-shaped, with white, torn, revolute edges ; peridial cells firmly united, warted all over, lozenge-shaped, and nearly iso-diametric, or elongated and oblong, with striated margins.

Aecidiospores variable in shape, irregularly globose or elliptic orange-yellow, smooth, $16-19 \times 12-17\ \mu$.

- III. Teleutosori long covered by epidermis, crowded together, pulvinate, black.

Teleutospores clavate to oblong, yellowish-brown, constricted at septum, smooth, $41-57 \times 17-25\ \mu$, average $47 \times 19\ \mu$; upper cell dark-brown, rounded or pointed, occasionally truncate and thickened at apex ; lower cell usually yellowish-brown and tapering towards base, elongated wedge-shaped ; pedicel persistent, pale-yellow or hyaline, up to $40\ \mu$ long and $9\ \mu$ broad.

- X. Mesospores common, coloured like teleutospores, elongated oblong or oval, thickened at apex, $32-43 \times 13-17\ \mu$.

On leaves and stems of *Erechtites quadridentata* DC., and *E. arguta* DC. Victoria—Ardmona, Dimboola, Myrning, and Marysville, Alps near Bright, and Mt. St. Bernard, &c.

On *E. quadridentata*, *E. arguta* and *E. prenanthoides* DC.

Tasmania—Huon Road, Dec., 1891, March, 1893, I. (Rodway).

On *Erechtites* sp.

New South Wales—Guntawang, I. (Hamilton).

- I. Very common all the year round, except during middle of summer.

- III. From January to June, but not so common.

The New South Wales specimen was named *Aecidium senecionis* Desm. by Cooke.

(Plates VII., Fig. 59 ; XXVII., Fig. 240.)

85. *Puccinia gnaphalii* (Speg.) P. Henn.

Hennings, Hedw. XLI., p. (66) (1902).

Morrison, Victorian Nat. XI., p. 120 (1894).

Sydow, Mon. Ured. I., p. 88 (1902).

Sacc. Syll. XVI., p. 295 (1902).

Uredo gnaphalii Speg. Fung. Arg. IV., p. 28 (1882).*Puccinia gnaphaliicola* P. Henn. Hedw. XXXVIII., p. (68) (1899).

- II. *Uredo-sori* common on stem and leaves, on the latter amphigenous, but mostly on under surface, bursting through and surrounded by epidermis, also piercing woolly tomentum, scattered, sometimes aggregated, compact, cinnamon, circular or oval, lenticular on stem, $\frac{1}{2}$ – $\frac{1}{3}$ mm. diam.

Uredospores globose, sub-globose or ellipsoid, brown, finely echinulate, 21 – $24\ \mu$ diam. or 21 – 26×17 – $21\ \mu$.

- III. Teleutosori similar, but chestnut-brown to black.

Teleutospores at first intermixed with uredospores, oblong or oblong-clavate, dark chestnut-brown, slightly constricted at septum, rounded or obtusely pointed or even beaked at apex, and thickened (up to $8\ \mu$), usually slightly attenuated towards base, smooth, 35 – 53×15 – $24\ \mu$, average $48 \times 20\ \mu$; pedicel hyaline, persistent, up to $66 \times 8\ \mu$.

- X. Mesospores similarly coloured, few, oval or elongated, elliptical, thickened at apex and sometimes beaked, 24 – 38×15 – $18\ \mu$.

On stems and leaves of *Gnaphalium purpureum* L., and *G. japonicum* Thunb.

Victoria—Oakleigh, Jan., 1904 (Morrison). Drysdale, Jan., 1896, and Oct., 1903. Whittlesea Ranges, Nov., 1898 (C. French, jun.) Killara, Oct., 1902. Near Melbourne, Feb. and Nov., 1904. Murramurrangbong Ranges, Nov., 1904 (Aitken).

The teleutospores are rather variable in length and breadth, sometimes being short and stout and sometimes rather elongated and slender. The pedicels average 40 – $50\ \mu$ in length, and may vary in breadth from $4\ \mu$ up to $10\ \mu$ at junction with spore. Sydow gives size of teleutospores as 32 – 56×18 – $24\ \mu$, and Dietel as 30 – 35×19 – $22\ \mu$.

I am indebted to Dr. Morrison for some of the original material from which he determined this fungus as *P. investita* Schwein. He found spermatogones immersed among spores in the sori, and the spermatia were fusiform. Plenty of *Darluca filum* Cast., was found, and no doubt these were mistaken for spermatogonia.

(Plate VII., Fig. 57.)

86. *Puccinia helianthi* Schwein.

Schweinitz, Syn. Carol., p. 73 (1821).

Cooke, Handb. Austr. Fung., p. 333 (1892).

Sydow, Mon. Ured. I., p. 92 (1902).

Sacc. Syll. VII., p. 603 (1888).

[O. Spermatogonia honey-colored, in small clusters.]

[I. Aecidia crowded or orbicular, or arranged in broadly expanded, oblong spots; pseudoperidia cylindrical, plane, with white lacinate margins.]

Aecidiospores orange-red, ellipsoid to polygonal, finely echinulate, $21-28 \times 18-21 \mu$.]

- II. Uredosori roundish, chestnut-brown, scattered or confluent, pulverulent, often on yellow or pale green spots on upper surface of leaf but generally forming brown mass on under surface.

Uredospires sub-globose, elliptic or obovate, golden-yellow, echinulate, epispore sub-hyaline, showing one germ-pore on one face, $21-24 \mu$ diam. or $24-29 \times 15-22 \mu$.

- III. Teleutosori roundish, dark-brown or black, prominent, scattered at first but ultimately in clusters, confluent, dotting both surfaces of leaf, but most prominent on under.

Teleutospires at first intermixed with uredospires, chestnut-brown, oblong-elliptical or pear-shaped, smooth, but occasionally a little rough at apex, slightly constricted at septum, thickened at apex ($6-9 \mu$), generally rounded at base, $36-50 \times 21-27 \mu$, average $44 \times 26 \mu$; upper cell similar in colour or just a shade darker than lower, and rather larger, $22-29 \times 21-27 \mu$; lower cell either the counterfeit of upper or slightly tapering towards base, $17-23 \times 20-22 \mu$; pedicel hyaline, persistent, generally much longer than spore, up to 90 and 110 μ long.

On leaves, branches, involucre bracts and corolla-leaves of *Helianthus annuus* L., and *H. tuberosus* L.

Victoria—Very common, December-April.

New South Wales—Mudgee and Guntawang, Feb., 1887 (National Herb.) (Hamilton). Sydney Botanic Gardens, Feb., 1901.

Queensland—Ipswich, 1888, Bailey⁵; Brisbane, 1889.

This rust was first observed in South Carolina and Pennsylvania, then it appeared in Russia where the sunflower is largely cultivated, and soon it spread over Europe, extending to Australia. The teleutospires are very regular and definite in shape.

Aecidia have not been found in Australia, although the rust is plentiful.

Sydow in his Monograph comes to the conclusion that this species possesses no aecidial stage, since he has examined specimens from numerous localities without result, but Carleton³ has collected the three stages in America and remarks:—"The aecidium occurs rarely in comparison with the occurrence of other stages, but it is to be found on a number of hosts and occasionally in considerable abundance. This rarity of its occurrence, together with the occurrence of spermogonia so often with the uredo, may be accounted for by the fact that the uredo is often produced by direct teleutosporic infection."

According to Woronin¹ the teleutospires germinate equally well whether they have been kept dry in a room or taken from leaves which had lain under the snow throughout the winter. Carleton² says that they also germinate at once without a resting period.

(Plate VII., Fig. 56.)

Hypochoeris.

87. *Puccinia hypochoeridis* Oud.

Oudemans in Nederl. Kruidk. Arch. II., Ser. 1, p. 175 (1873).

Sydow, Mon. Ured. I., p. 100 (1902).

Sacc. Syll. VII., p. 634 (1888); XVII., p. 302 (1905).

Puccinia microseris McAlp., Agr. Gaz. N.S.W. VI., p. 757 (1895).

- II. Uredosori amphigenous or frequently on stem, generally seated on minute spots, scattered, pulverulent, cinnamon-brown.

Uredospores globose, sub-globose or ellipsoid, echinulate, pale-brown, with one prominent germ-pore on one face, $21-25\ \mu$ diam. or $20-28 \times 18-24\ \mu$.

- III. Teleutosori amphigenous, often on stem, scattered or crowded, punctiform, blackish to dark-brown, pulverulent, generally roundish on leaf and up to 1 mm. diam., but often smaller, elongated on stem and up to 2 mm. long.

Teleutospores at first intermixed with uredospores, oblong, ellipsoid or obovate, apex generally rounded, and not thickened, rounded at base or slightly attenuated, hardly constricted at septum, dark-brown, very delicately punctate, occasionally tri-cellular, $30-49 \times 17-24\ \mu$, average $32 \times 20\ \mu$; pedicel hyaline, generally deciduous, sometimes persistent and may reach a length of $77\ \mu$.

On *Hypochoeris radicata* L., very common.

Victoria—Dimboola, Nov., 1889 (Reader). Ardmona, 1894 (Robinson). Myrniong, March, 1900 (Brittlebank). Near Melbourne, Apr., 1901. Dookie, Oct., 1903. Altona Bay, Oct., 1903 (C. French, jun.). Murramurrangbong Ranges, Dec., 1903 (Robinson).

New South Wales—Wagga (Maiden).

On *H. glabra* L.

Victoria—Dimboola, Nov., 1889, and July, 1892 (Reader).

Queensland—Brisbane, 1886 (Bailey⁵).

The punctuation on the teleutospores is so fine that it may easily be overlooked, but when the spores are mounted in water it is clearly seen.

A specimen from Syd. Ured. Exs. 673 on *H. glabra* agreed very closely, the uredospores being on an average $25 \times 21\ \mu$, and the teleutospores $34 \times 18\ \mu$.

This species closely resembles in morphological characters *P. hieracii* (Schum.) Mart., but Jacky has shown by means of cultures that the latter can only grow on *Hieracium* species, and cannot be transferred to other genera of Composites. Occasionally there may be a three-celled teleutospore reaching a length of $56\ \mu$.

P. microseris described as a new species in the Agricultural Gazette of New South Wales was based upon a wrong determination of the host-plant by the collector since it was afterwards found to be *Hypochoeris radicata* L.

Darlucula filum Cast., is sometimes common on the mixed uredo and teleutosori.

(Plate VIII., Figs. 62, 63.)

Helichrysum.

88. *Puccinia kalchbrenneri* De Toni.

De Toni in Sacc. Syll. VII., p. 645 (1888).

Cooke, Handb. Austr. Fung., p. 337 (1892).

Sydow, Mon. Ured. I., p. 93 (1902).

- II. Uredosori on both surfaces, but mostly on under, seated on indeterminate spots which are often confluent and variously coloured, scattered or gregarious, minute, at first covered, convex, firm, ultimately free and discoid, ochraceous.

Uredospores globose, subglobose or ellipsoid, warted, yellow to pale brown, $20-30 \times 19-26 \mu$.

III. Teleutosori hypophyllous, seated on the same spots, minute, brown.

Teleutospores oblong or subclavate to lanceolate, apex thickened, attenuated or rarely truncate, constricted at septum, smooth, dark-brown, $40-57 \times 15-22 \mu$, rarely up to 27μ broad; pedicel hyaline, short, deciduous.

On living leaves of *Helichrysum* sp.

Victoria.

There is no specimen of this species from Australia in the Kew Herbarium, and I have not found it on any species of *Helichrysum*, though this genus is exceedingly common near Melbourne.

Lagenophora.

89. **Puccinia lagenophorae** Cooke.

Cooke, Grev. XIII., p. 6 (1884).

Cooke, Handb. Austr. Fung., p. 335 (1892).

Sydow, Mon. Ured., I., p. 111 (1902), and p. 863 (1904).

Sacc. Syll. VII., p. 612 (1888).

P. hypochoeridis McAlp., Proc. Roy. Soc. Vic. VII., N.S., p. 217 (1894).

P. macalpini Sydow, Mon. Ured., I., p. 100 (1902).

I. Aecidia amphigenous, spots none; pseudoperidia scattered or in groups, semi-immersed, margin lacerated, white, $200-240 \mu$ diam.; peridial cells finely warted, lozenge shaped or elongated, $24-31 \mu$ long.

Aecidiospores subglobose or elliptical, orange-yellow, very finely echinulate, $12-14 \mu$ diam. or $17-19 \times 14 \mu$.

[II. Uredosori scattered, small, pulverulent, brown or mixed with teleutosori.

Uredospores globose, brown, epispore rough, 20μ diam.]

III. Teleutosori amphigenous, scattered, or surrounding aecidia, rather compact, dark-brown to black, raising and rupturing epidermis.

Teleutospores clavate, constricted at septum, dark-brown only in upper cell, epispore thickened, smooth, $45-66 \times 16-22 \mu$, average $49 \times 17 \mu$; upper cell subglobose or oblong or somewhat conical, rounded, flattened, or bluntly pointed at apex, which is considerably thickened, generally equal in length to lower cell; lower cell pale in colour, attenuated into pedicel and narrower than upper cell; pedicel persistent, generally slightly tinted, attaining a size of $42 \times 7 \mu$.

X. Mesospores relatively numerous, pale coloured, elongated elliptical, thickened at apex, with persistent hyaline pedicel, $38-42 \times 16-17 \mu$.

On stems and leaves of *Lagenophora billardieri* Cass.

Victoria—Omeo, 1884 (Stirling). Ardmona, Oct., 1894 (Robinson). Near Melbourne, Sept., 1900, I. (C. French, jun.) Murramurrangbong Ranges, Nov., 1902, Dec., 1903, Jan., 1905 I., III. (Robinson).

On *L. huegelii* Benth., and *L. billardieri* Cass.

Tasmania—Mt. Dromedary, near Hobart, Dec., 1894, I. (Rodway¹). Mt. Direction, Oct., 1895, I., III. (Rodway¹). Devonport, Jan., 1906 (Robinson).

Although material was very plentiful, careful search failed to reveal the presence of uredospores, and I have given them on the authority of Cooke. Massee informs me that *P. lagenophorae* Cooke, is not represented in the Kew Herbarium, and he, therefore, cannot refer to the type specimens. I have examined scores of plants with this rust upon them from different localities and at different seasons, and I have never found uredospores.

The leaves on which *P. hypchoeridis* McAlp., was found proved to be not *Hypchoeris radicata* but *Lagenophora billardieri*, and the fungus agreed with the above.

(Plate VII., Figs. 54, 55 ; Plate F., Fig. 27.)

Podolepis.

90. *Puccinia podolepidis* McAlp.

O. Spermatogonia on small, honey-coloured spots, forming minute, dark-coloured points, hemispherical, pale yellow by transmitted light, with round mouth, without projecting paraphyses, about 120 μ diam. Spermatia minute, hyaline, oval, $3 \times 2 \mu$.

I. Aecidia bright orange, on both surfaces of the leaf, numerous, generally arranged in circular groups, which, however, often coalesce into large patches ; pseudoperidia cup-shaped, embedded in tissue, with white reflexed, lacinate margins ; peridial cells oblong to lozenge shaped, with striated margins, $28-32 \times 16-18 \mu$.

Aecidiospores deep orange, ellipsoid to subglobose, smooth, $24-32 \times 16-22 \mu$, or $22-24 \mu$ diam.

III. Teleutosori black, surrounding the aecidia.

Teleutospores chestnut-brown, oblong to clavate, constricted at septum, smooth, rounded or truncate or occasionally pointed and thickened at apex ($9-12 \mu$), rounded or attenuated towards base, upper cell darker than lower, $38-54 \times 22-32 \mu$; pedicel persistent, hyaline, relatively short.

X. Mesospores common, similarly coloured to teleutospores or often paler, ellipsoid, obovate to wedge-shaped or subclavate, rounded and thickened at apex, pedicellate, $32-44 \times 16-22 \mu$.

On leaves of *Podolepis longipedata* A. Cunn.

Victoria—Buffalo Mts., Nov., 1903, I. (C. French, jun.). Alps, near Bright, Dec., 1904, I., III. (C. French, jun.).

Several teleutospores had two germ pores in upper cell, one on either side, but only one in lower cell.

The teleutosori were rather sparse.

(Plate XXIX., Figs. 256, 257.)

Lactuca.

91. *Puccinia prenanthis* (Pers.) Lindr.

Lindroth, Myk. Mittheil, p. 6 (1901).

Cooke, Handb. Austr. Fung., p. 334 (1892).

Sydow, Mon. Ured. I., p. 106 (1902).

Sacc. Syll. XVII., p. 306 (1905).

- I. Aecidia hypophyllous, a few rarely epiphyllous, or on petioles, seated on orbicular or elongated yellow or purple spots, up to 1 cm. in diam., in round or irregular groups, at first hemispherical, then flat, yellow or whitish, sometimes yellowish purple.

Aecidiospores globose, subglobose or ellipsoid, delicately warted, pale orange, 13–24 μ diam.

- II. Uredosori hypophyllous, on pale indeterminate irregular spots, scattered, minute, punctiform, pulverulent, pale brown.

Uredospores globose or subglobose, echinulate, yellowish-brown, 16–24 μ diam.

- III. Teleutosori similar, girt by the ruptured epidermis, dark-brown.

Teleutospores ellipsoid, rounded but not thickened at apex, mostly rounded at base, not constricted at septum, delicately warted, brown, 26–36 \times 16–24 μ ; pedicels hyaline, very short.

On living leaves of *Lactuca*.

Victoria, New South Wales, S. Australia.

No specimen seen. It is given on the authority of Cooke, but Mueller² only records the aecidial stage for Victoria. The aecidial wall is very imperfectly formed in this species, and there is a close approach to caecoma forms.

Senecio.

92. *Puccinia tasmanica* Diet.

Dietel, Ann. Myc. I., p. 535 (1903).

Sydow, Mon. Ured. I., p. 867 (1904).

Sacc. Syll. XVII., p. 277 (1905).

- I. Aecidia on blister-like swellings on stem and branches, on upper and under surface of leaves, on flower-head stalks and involucre, causing discoloration and distortion, and usually surrounded by paler green tissue, about $\frac{1}{3}$ mm. in diam., disposed in large circular or oval clusters or irregularly; pseudoperidia cup shaped, with white, irregularly lacinated everted edges, tubercular before opening; peridial cells firmly united, overlapping each other, with striated margins and usually broader at one end, individually slipper-shaped, 25–35 \times 13–17 μ .

Aecidiospores spherical or angular, orange colored, very delicately warted, 13–16 μ diam., or 14–17 \times 11–15 μ .

- III. Teleutosori for a long time covered by epidermis, then erumpent and epidermis usually thrown off or remaining in shreds and patches, intermixed or running parallel with aecidia, black, pulvinate, oval, up to 1 mm. long, often confluent in elongated lines.

Teleutospores oblong to clavate, chestnut-brown, slightly constricted at septum, smooth, 36–63 \times 15–25 μ , average 54. \times 20 μ , occasionally tricellular when 48–73 μ long; upper cell deep chestnut-brown, rounded or somewhat oval, conoid, or truncate and thickened at apex (up to 13 μ); lower cell usually paler in colour, rounded at base or tapering, often elongated relatively to upper; pedicels persistent, pale yellow to hyaline, sometimes longer than spore.

- X. Mesospores very common, elongated oval, oblong, or somewhat elliptical, apex rounded or pointed and usually thickened, golden-yellow to chestnut-brown, 29–44 \times 13–17 μ .

On leaves and stems of *Senecio vulgaris* L.

Victoria (Ralph), (Robinson), (French, junr.), &c., I. III.

New South Wales (Hamilton), I.

Tasmania—1891, 1893, 1895, 1897, I. III. (Rodway ¹).

On *Senecio pectinatus* DC.

New South Wales—Mount Kosciusko, Jan., 1898, I. (Maiden).

On *Senecio brachyglossus* F.v.M.

Victoria—August, 1900, I. (Reader).

On *Senecio velleioides*, A. Cunn.

Victoria—Sealers' Cove, 1854, I. Port Phillip, 1886, I.

It differs from *P. senecionis* Lib., in the aecidia being amphigenous and not hypophyllous; also in the teleutospores being considerably larger, thickened at apex, and not provided with a hyaline papilla, while the pedicel is decidedly persistent and elongated. Groundsel, or *S. vulgaris*, being an imported plant, and so cosmopolitan in its character, it was considered strange that a new species of rust should be found upon it, and although I had named it in MS. *P. australiensis*, yet I delayed publishing it under that name, hoping to find the teleutospores on a native *Senecio*.

Teleutospores are very common in some localities during the winter and spring months, and the Groundsel growing on the coast at Port Fairy was so overrun with both aecidia and teleutosori that the plants were stunted in growth.

S. pectinatus DC., occurs in the three States from which *Puccinia tasmanica* has been recorded, but only the aecidial stage has been met with in New South Wales.

(Plate VII., Fig. 52.)

Vittadinia.

93. *Puccinia vittadiniae* McAlp.

- I. Aecidia on both surfaces of leaf, but mostly on upper, scattered or in groups and confluent, minute; pseudoperidia white becoming yellowish, immersed, with lobed margin; peridial cells with striated margin in section, striae projecting and appearing as points in surface view, oblong, $25-32 \times 13-16 \mu$.

Aecidiospores yellowish, ellipsoid, very finely verrucose, $14-17 \times 11-13 \mu$.

- III. Teleutosori minute, black, sparsely developed, intermixed with aecidia.

Teleutospores dark chestnut-brown, oblong to elongated oblong or clavate, smooth, constricted at septum, generally rounded at base and apex, sometimes bluntly pointed or truncate, and thickened at apex ($6-9 \mu$), $31-46 \times 18-25 \mu$, average $34 \times 21 \mu$; upper cell darker than lower and similar or sometimes considerably broader; pedicel hyaline, persistent, $30-40 \mu$ long, and up to 9μ broad adjoining spore.

- X. Mesospores very common, similarly coloured to teleutospores and stalked, ovoid to elongated ellipsoid, rounded or beaked at apex and thickened (up to 9μ), $25-34 \times 14-17 \mu$.

On leaves including leaf stalks of *Vittadinia australis* A. Rich.

Victoria—Dimboola, June, 1900 (Reader).

In Agr. Gaz. N.S.W. VI., p. 757 (1895), I described a new species under the name of *Aecidium vittadiniae* upon a plant forwarded to me as *Vittadinia australis*, but which was afterwards found to be an *Erechtites*, so that the present description replaces the previous one.

(Plates XXXIX., Fig. 292 ; XLIII., Figs. 308, 309.)

RUBIACEAE.

Coprosma.

94. *Puccinia coprosmae* Cooke.

Cooke, Grev. XIX., p. 2 (1890).

Sydow, Mon. Ured. I., p. 209 (1902).

Sacc. Syll. IX., p. 300 (1891).

P. coprosomatis Morrison, Vict. Nat. XI., p. 90 (1894).

- III. Teleutosori hypophyllous, sometimes epiphyllous, rusty-brown, prominent, compact, round or elliptic, usually in groups, sometimes forming mammilated tubercles, rarely solitary, densely crowded and confluent, sometimes surrounded by the ruptured epidermis or naked and deforming the leaves.

Teleutospores elongated oblong to clavate, pale yellowish to brownish, the two cells about equal and more or less ovate, apex bluntly pointed or rounded, thickened, (from $6-8\ \mu$), rounded or slightly tapering at base, smooth, constricted at septum, $35-51 \times 16-22\ \mu$, average $43 \times 18\ \mu$; pedicel hyaline, persistent, elongated, up to $110\ \mu$ long and $8\ \mu$ broad.

- X. Mesospores common, similarly coloured to teleutospores, ovoid to ellipsoid, or somewhat fusoid, usually pointed and thickened at apex, $32-41 \times 19-22\ \mu$.

On leaves of *Coprosma billardieri* Hook.

Victoria—Kew and Dandenong, Oct. and Feb., 1893.

Tasmania—(Rodway¹).

On *Coprosma hirtella* Labill.

Victoria—Murrumbidgee Ranges, Dec. 1903, Jan. 1905 (Robinson).

I am indebted to Dr. Morrison for some of the original material on which he founded his new species *P. coprosomatis*, but it is identical with the above species first determined by Dr. Cooke on *Coprosma lucida* from New Zealand.

Darlucium pilum Cast., was very plentiful on the teleutosori on *Coprosma billardieri*, and was described by Morrison as a spermogone with spermatia.

(Plate X., Fig. 78.)

Asperula.

95. *Puccinia oliganthae* McAlp.

- II. Uredosori hypophyllous, cinnamon-brown, round to ellipsoid, soon naked, girt by the ruptured epidermis, confluent into elongated patches.

Uredospores globose to shortly elliptical or obovate, golden-brown, finely echinulate, one to two germ-pores on one face, $25-29 \times 22-25 \mu$, or $25-27 \mu$ diam.

- III. Teleutosori on stems, dark-brown to black, elongated, bullate, soon naked, compact, 2 mm. long or more.

Teleutospores narrowly clavate to oblong, brown, constricted at septum, thickened at apex ($9-10 \mu$), and rounded or bluntly pointed, or may be truncate, lower cell generally attenuated towards base and paler in colour, $32-54 \times 16-21 \mu$, average $48-16 \mu$; pedicel yellowish, persistent, up to 48μ long.

- X. Mesospores occasional, similarly coloured to teleutospores, somewhat fusiform, with pointed and thickened apex, $28-32 \times 12-13 \mu$.

On stem and leaves of *Asperula oligantha* F. v. M.

Victoria—In shady gullies of Murramurrangbong Ranges, Nov., 1902 (Robinson).

The examination of specimens of *P. punctata* Link, on species of *Asperula* from Exsicc. Sydow Ured. 465, 466, showed that the two were distinct. In *P. oligantha* the uredospores are broader, and while the teleutospores average only about $16-18 \mu$ broad, in *P. punctata* they are about $20-22 \mu$. In the latter too the apex is much thicker, reaching up to 16μ . The species closely resembles *P. asperulae odoratae* Wurm, but aecidia are present on the latter, and the teleutospores are only thickened at the apex to the extent of 7μ .

(Plate X., Fig. 77.)

Opercularia.

96. *Puccinia operculariae* (Morr.) Syd.

Morrison, Victorian Nat. XI., p. 119 (1894).

Sydow, Mon. Ured. I., p. 224 (1902).

Sacc. Syll. XIV., p. 321 (1899); XVII., p. 317 (1905).

Aecidium cystoseioides Berkeley, Fl. Tasm., p. 270 (1860).

- I. Pustulate, deforming the leaves; pseudoperidia immersed.

Aecidiospores orange, subangular.

- III. Teleutosori hypophyllous, on orbicular brownish to yellowish spots, solitary or a few together, round or elliptic, compact, reddish-brown, girt or partially covered by the ruptured epidermis, up to 2 mm. long.

Teleutospores golden-brown, oblong to oblong clavate, constricted at septum, smooth, $35-54 \times 14-20 \mu$; upper cell rounded or pointed and thickened at apex (up to 11μ), about equal in length to lower; lower cell usually tapering towards base or sometimes rounded; pedicel hyaline, persistent, 80μ or more long and $6-7 \mu$ broad.

On living leaves of *Opercularia aspera* Gaertn.

Victoria—Genoa River (F. V. Mueller).

On leaves and petioles of *Opercularia varia* Hook. f.

Victoria—Oakleigh, Nov., 1893 (Morrison).

Tasmania—Near Hobart Rivulet, Nov., 1860, I. (Gunn), 1902 (Rodway¹).

Morrison states that this fungus deforms the leaf and produces a cavity on the opposite side. He made this a variety of *P. coprosmae* Cooke, and certainly there is a very close resemblance, but the sori in the latter are generally in groups, and the apex of the spore is not quite so thick.

No specimens of the aecidial stage were seen, but being on the same host-plant as the teleutospores, it is included in this species.

Darluka filum Cast., is common on the teleutosori, although it is usually only found on uredosori.

(Plate XXIX., Fig. 258.)

LORANTHACEAE.

Loranthus.

97. *Puccinia loranthicola* McAlp.

- I. Aecidia imbedded in raised brownish to dark brownish, often confluent cushions on one or both surfaces of leaf, orange; pseudo-peridia tubular, with white, reflexed, much torn margins; peridial cells oblong, with striated margins, $43-50 \times 27-31 \mu$.

Aecidiospores ellipsoid to oblong or sub-angular, bright orange yellow, decidedly echinulate, $37-56 \times 22-31 \mu$.

- II., III. Uredosori amphigenous, brownish, bullate, in scattered groups, often arranged in circles and confluent, surrounding central darker teleutosori, epidermis splitting lengthwise and persistent.

- II. Uredospores orange yellow, ellipsoid to oval, obovate or oblong, coarsely echinulate, with 3-5 equatorial germ-pores on one face, $40-65 \times 22-32 \mu$, occasionally $80 \times 22 \mu$; epispore $3-4\frac{1}{2} \mu$ thick.

- III. Teleutospores intermixed with uredospores, subhyaline, cylindrical to clavate cylindrical, smooth, slightly constricted at septum, rounded and slightly or not at all thickened at apex, tapering slightly towards base, $65-94 \times 15-24 \mu$, occasionally 3-celled, when about 86μ long; pedicel hyaline, persistent, elongated up to 200μ long, and swollen towards apex up to 14μ .

- X. Mesospores subhyaline and with elongated pedicel like that of teleutospore, smooth, fusoid, hardly thickened at apex, $71-77 \times 25-28 \mu$.

On living leaves of *Loranthus celustroides* Sieb., growing on Stringybark (*Eucalyptus* sp.).

Victoria—Murramurrangbong Ranges, Jan., 1905 (Robinson).

All the stages were found on the same trees, but the aecidia on separate leaves. All the spore-forms are particularly large, a fact which probably has some relation to the peculiar nutrition of the fungus, and the height at which it occurs, some specimens being obtained fully 50 feet from the surface of the ground.

The aecidia are very conspicuous on raised cushions, with corresponding depressions on the opposite side, where aecidia may also occur.

The uredosori are of a ruddy brown, in isolated groups, generally arranged circularly and with teleutosori in the centre. *Puccinia loranthi* Speg., has only teleutospores, and it is doubtful if they are to be regarded as such. *P. macrocarya* Rac. on leaves of *Loranthus* in Java has only aecidia and teleutospores.

(Plate XXXI., Figs. 268-271.)

UMBELLIFERAE.

Apium.

98. *Puccinia thuemeni* (Thuemen) McAlp.*P. castagnei* Thuemen, Rev. Myc. II., p. 86 (1880).

- O. Spermogonia on both surfaces of leaf, pale yellow, round, in groups on minute raised yellow spots, about $150\ \mu$ diam.

Spermatia hyaline, ellipsoid, $3.5-4 \times 2-2.5\ \mu$.

- II. Uredosori amphigenous, bullate, round or ellipsoid, scattered or crowded, and becoming confluent, surrounded or partially covered by the ruptured epidermis, pulverulent, cinnamon-brown, 1 mm. or more long.

Uredospores obovate to ellipsoid, golden-brown, echinulate, with thickened hood-like apex ($7-8\ \mu$), and three or four, more or less equatorial germ-pores on one face, $25-38 \times 19-22\ \mu$, average $30-32 \times 21\ \mu$; the hyaline pedicel may reach a length of $56\ \mu$.

- III. Teleutosori similar to uredosori, dark-brown, also on both surfaces of leaf, but more common on under.

Teleutospores similarly coloured to and intermixed with uredospores, shortly oblong to ovate-oblong, slightly or not at all constricted at septum, finely warted, rounded at apex, and not perceptibly thickened, $29-40 \times 16-22\ \mu$, average $32 \times 20\ \mu$; lower cell rounded at base or slightly attenuated; pedicel hyaline, short, deciduous.

On stems and leaves of *Apium prostratum* Labill.

Victoria—Beaumaris, Dec.—July, II., III. (III. in April).
Portland, Jan., 1901, II., III. Sandringham, Jan. and Feb.,
1904, II., III. (III., very sparse). Mentone, Jan.—Sept.,
1905, II. III.

Tasmania—Hobart, Sept., 1905 (Rodway). Mersey River, January,
1906 (Robinson).

It may be found in sheltered spots all the year round.

On *Apium graveolens* L.

Victoria—Near Melbourne, April—Sept., II. III.

Tasmania—Hobart, Sept., 1905 (Rodway).

Very common in the early spring months.

Spermogonia were only found on the native celery (*Apium prostratum*) associated with uredospores and teleutospores.

The germ-pores of the uredospores may be in a transverse band, or one may be placed above the other. When fully developed the uredospores are similarly coloured to the teleutospores, otherwise they are yellowish. On *Apium graveolens* both uredospores and teleutospores agree almost exactly in average size, though of the latter there are usually very few more than $33\ \mu$ in length. There are occasionally elongated teleutospores which reach a length of $40\ \mu$. The finely warted epispore is a constant feature of the teleutospores on both hosts.

The illustrations of spores in Pl. IX., Figs. 68-72, show that the rust on the native celery (*Apium prostratum*), and on cultivated celery (*A. graveolens*) is the same in Australia. Figs. 73, 74 show the smooth teleutospores of *P. apii* Corda on *Apium graveolens* from Sydow's Ured. Exsicc., 558, which is quite distinct from the finely warted *P. thuemeni*, and Fig. 75 shows the very rough and knobby teleutospores of *P. bullata* (Pers.) Schroet.

on *Aethusa cynapium* from Sydow's Ured. Exsicc., 1261, which is readily distinguishable from either of the above. There is thus a clear distinction between these three recognised species, but the synonymy is rather confusing. The reason for the name I have adopted may first be given. *P. castagnei* Thuem., on cultivated celery agrees with our species, but *P. castagnei* Schroet., in Cohn's Beiträge, III., 62 (1879), was first applied to a *Puccinia* on *Thalictrum angustifolium*, and Thuemen's name being thus preoccupied, I have substituted *P. thuemeni*.

As regards the synonyms, Cooke, in his Australian Handbook, gives *P. apii* Corda at first, and then in an addendum substitutes *P. castagnei* Thuem. for it.

Then Saccardo, in his Sylloge, gives *P. bullata* with *P. apii* as a synonym, and *P. castagnei* is regarded as distinct. Further, Sydow in his Monograph includes *P. apii* Corda, and *P. castagnei* Thuem., under *P. apii* Desm., and *P. bullata* is given separately, although he remarks that the latter is probably a collective species. The teleutospores of *P. bullata* are described as smooth, and therefore do not agree with the quoted specimen from Sydow. Finally, it may be noted that Tranzschel¹ has shown that the host-plant of *P. castagnei* Schroet., is not *Thalictrum angustifolium*, but an Umbellifer, and probably *Silene pratensis*, so that this species is a synonym of *P. bullata*.

Darluca filum Cast., occurs on the uredosori and teleutosori.

(Plate IX., Figs. 68-75 ; Plate C., Figs. 16, 17.)

Xanthosia.

99. *Puccinia xanthosiae* McAlp.

II. Uredosori amphigenous, and on leaf-stalks, dark-brown, pulvinate, gregarious, elliptical, often confluent, rupturing epidermis, about $\frac{3}{4}$ mm. long, often causing entire leaf to become brownish.

• Uredospores golden-brown, thick-walled, echinulate, globose to elliptical, 30-32 μ diam., or 30-37 \times 24-28 μ , average 34 \times 26 μ ; pedicel colourless, 4-6 μ broad.

III. Teleutosori rare, on leaves of previous year, minute, black.

Teleutospores oblong to oblong clavate, dark-brown, smooth, constricted at septum, 40-60 \times 20-25 μ , average 42 \times 20 μ ; upper cell generally darker than lower, rounded and slightly thickened at apex, occasionally truncate; lower cell rounded at base or attenuated towards stalk; pedicel persistent, tinted, about 20 μ long.

X. Mesospores occasional, similarly coloured to teleutospores, obovate, thickened at apex, 32 \times 20 μ .

On *Xanthosia pusilla* Bunge.

Victoria—Frankston, Oct., 1899, II.; Oct., 1903, III. Sandringham, Sept., March, II, III.; Feb., II.

(Plate IX., Fig. 76.)

ONAGRACEAE.

*Epilobium.*100. *Puccinia epilobii-tetragoni* (DC.) Wint.

Winter, Pilze, p. 214 (1884).

Sydow, Mon. Ured. I., p. 424, (1902).

Sacc. Syll. VII., p. 608 (1888).

- I. Aecidia distributed over the entire surface of the leaf, scattered or crowded, hypophyllous; pseudoperidia cup-shaped, with white, lacinate, revolute margins.

Aecidiospores orange yellow, polygonal, finely warted, 16–26 μ diam., 18–21 μ being common.

- II. Uredosori chestnut-brown, scattered, or often orbicularly arranged, sometimes confluent, pulverulent, hypophyllous, soon naked.

Uredospores ellipsoid or ovoid, clear brown, echinulate, with two germ-pores on one face, 21–27 \times 16–21 μ , occasionally reaching a length of 31 μ .

- III. Teleutosori dark-brown, round, often arranged on ring-like spots, hypophyllous, soon naked, pulverulent.

Teleutospores intermixed with uredospores, elliptic or oblong, yellowish-brown, slightly constricted at septum, smooth, 27–36 \times 15–21 μ , average 30 \times 18 μ ; upper cell with a cap-like thickening at apex (5–6 μ); lower cell usually rounded at base or sometimes slightly tapering; pedicel hyaline, slender, deciduous, short.

- X. Mesospores exceedingly rare, similarly coloured to teleutospores and thickened at apex (5 μ), subclavate to obovoid, smooth, 21–27 \times 13–15 μ , with hyaline pedicel.

On leaves of *Epilobium glabellum* Forst.

Victoria—Dimboola, Dec., 1892, I., II., III. (Reader). Ardmona, Arthur's Creek, Kergunyah, Nyora, Pakenham, &c., Aug. Dec., I., II., III.

On *E. billardierianum* Ser.

Tasmania—Great Lake, Feb., 1894 (Rodway¹).

On *Epilobium* sp.

Tasmania—Summit of Mt. Wellington, Jan. 1892, I. (Rodway).

Sydow, in his Monograph, distinguishes between *P. epilobii* DC., with teleutospores alone, *P. epilobii-fleischeri* Fisch., with aecidia in addition to teleutospores, and the present species with the three stages.

(Plate X., Figs. 79, 80, 81.)

ROSACEAE.

*Geum.*101. *Puccinia gei* McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 756 (1895).

Sydow, Mon. Ured. I., p. 484 (1903).

Sacc. Syll. XIV., p. 297 (1899).

- III. Teleutosori hypophyllous, confluent, coffee-brown, on greenish-yellow spots, which also occur on upper surface of leaf.

Teleutospore brownish-yellow, smooth, fusiform to clavate, constricted at septum, epispore chestnut-brown, $30-40 \times 13-18 \mu$, average $35 \times 14 \mu$; upper cell elongated and tapering or rounded, thickened at apex, $18-22 \mu$ long; lower cell elongated and tapering towards base, or bulging, $16-22 \mu$ long; pedicel pellucid, sometimes 54μ long.

- X. Mesospores occasional, coloured like teleutospores, elongated ellipsoid to oblong, rounded and thickened at apex, occasionally somewhat pear-shaped, and the basal portion prolonged like a stalk, as sometimes happens in the bicellular spore, $28-35 \times 12-18 \mu$.

On living leaves of *Geum renifolium* F. v. M.

Tasmania—The Calf, Adamson's Peak, March, 1895 (Rodway¹).

The specimen was gathered on an out-of-the-way mountain, at an altitude of nearly 4,000 ft.

(Plate X., Fig. 82.)

Prunus.

102. *Puccinia pruni* Pers.

Persoon, Syn. Fung., p. 226 (1808).

Cooke, Grev. XI., p. 97 (1883).

Sydow, Mon. Ured. I., p. 484 (1903).

Sacc. Syll. VII., p. 648 (1888).

- II. Uredosori hypophyllous, occasionally epiphyllous, minute, light brown to cinnamon brown, orbicular, scattered, but often grouped in patches and confluent, soon naked, pulverulent, usually seated on discoloured spots, which also show on upper surface.

Uredospores variable in shape, oblong to ovoid oblong, ellipsoid to somewhat piriform, closely echinulate, yellowish, with two or occasionally three sub-equatorial germ-pores on one face, apex yellowish brown, thickened (average, $5-6 \mu$, or papillate up to 9μ) with spines less prominent, bluntly conical or rounded, $25-38 \times 12-18 \mu$, occasionally reaching a length of 40μ or more, average $30 \times 15 \mu$; paraphyses intermixed, numerous, capitate, pale yellow, long-stalked, sometimes attaining a length of 70μ .

- III. Teleutosori hypophyllous, scattered or confluent, isolated or in groups, very pulverulent, seal-brown, paraphysate, known from the uredosori when fully developed by their dark, almost black appearance.

Teleutospores at first intermixed with uredospores, dark-brown, oblong to ellipsoid or obovoid, densely warted, often composed of two globose or depressed globose cells, readily separating from each other, very rarely 3-celled, $25-45 \times 17-25 \mu$, average $36 \times 25 \mu$; upper cell usually darker in colour, and broader than lower, globose or depressed globose, often slightly thickened at apex, and thickly studded with short stout spikes, average $16-22 \mu$ diam.; lower cell generally oblong to obovoid, and equal to or longer than upper, $14-24 \times 14-19 \mu$; pedicel short, hyaline, deciduous.

On leaves, fruits and stems of Peach (*Prunus persica* Stokes).

On leaves and fruits of Almond and Apricot (*Prunus amygdalus* Stokes, and *P. armeniaca* L.).

On leaves of Plum (*Prunus domestica* L.) and Nectarine.

Victoria, New South Wales (Cobb¹), Queensland (Bailey⁵) (Tryon¹), South Australia, West Australia, and Tasmania (Rodway¹).

Common. November to June, the teleutospores being very common in March on *Prunus domestica*.

This rust is usually most prevalent towards the autumn, but in some seasons it appears in the early summer. It not only destroys the foliage, but may even attack the fruit, and in some seasons it actually ruptures the bark, especially in rapidly growing nursery stock. When the rust occurs on the fruit, uredospores may be produced both at the surface and in the pulp.

There are said to be two kinds of uredospores by Dumée and Maire¹, but T³³ have shown that this is simply due to an error of interpretation, and that they are always thickened at the apex when seen in their natural position, and not obliquely. Teleutospores are comparatively rare on the Apricot and Peach, less so on the Almond, and very common on the Plum. In April, 1904, both stages of the rust were found on leaves of all the host-plants. According to Prillieux¹, teleutospores often appear alone, without having being preceded by uredospores, but this has never been known to occur in Australia. The arrangement of the teleutospores in the sorus is worthy of note. With a magnifying glass the spores can be seen to be arranged in minute clusters, and each cluster under the microscope is seen to consist of a number of spores, the stalks of which have become agglutinated together, and to the free end of each a spore is attached. (McAlpine³⁴).

On the leaves of the Peach the sori are situated on yellow spots, which are very prominent on the upper surface. There they often run together, and have the appearance of yellow ochre. In the Apricot the spot is hardly noticeable at first, but when held up to the light the indeterminate yellow spots are seen clearly. The leaf soon turns yellow, and then the spots are of a pale green. In the Plum the spots are very pale on the lower surface, but on the upper surface the yellowish-green is very prominent.

Tranzschel² has proved experimentally that the aecidial stage of the rust on Almond occurs on *Anemone coronaria* L., and it has hitherto been known as *Aecidium punctatum* Pers.

Darlucu filum Cast., is found on the uredosori.

(Plate X., Figs. 83–86; Plate D., Figs. 19, 20.)

LEGUMINOSAE.

Zornia.

103. *Puccinia zorniae* (Diet.) McAlp.

Uredo zorniae Dietel, Hedwigia XXXVIII., p. 257 (1899).

- II. Uredosori on both surfaces of leaf, but most numerous on under, yellowish when young, then ruddy-brown, round to elliptic, bullate, at first covered, then erumpent and surrounded by ruptured epidermis, gregarious and sometimes confluent.

Uredospores old-gold colour, ellipsoid to occasionally obovoid, finely echinulate, with two germ-pores on one face, $25-32 \times 19-22 \mu$.

- III. Teleutosori as above, but dark-brown.

Teleutospores intermixed with uredospores and similarly coloured, oblong, smooth, deeply constricted at septum, two cells about equal in size or lower sometimes a little longer, $32-44 \times 20-24 \mu$, average $36 \times 21 \mu$; upper cell rounded and thickened at apex (up to 6μ), lower cell rounded at base; pedicel hyaline, persistent, about length of spore.

On living leaves of *Zornia diphylla* Pers.

New South Wales—Richmond River, May, 1904 (Musson).

Uredo zorniae Berk., is mentioned by Cooke in Grev. XX., p. 110, as on *Zornia* in Mauritius, but no diagnosis is given. This is the first record of the teleuto stage, since Dietel in his *Uredineae brasilienses* only mentions the uredo stage on the same plant from Rio Janiero, and thus describes it:—"Sori hypophyllous, scattered, surrounded by the ruptured ochraceous epidermis, minute, brown. Uredospores globose, obovate or ellipsoid, $21-28 \times 18-23 \mu$; episporium brown, echinulate, with three germ-pores."

Darluka filum Cast., occasionally on sori.

(Plate X., Fig. 87.)

FICOIDEAE.

Tetragonia.

104. *Puccinia tetragoniae* McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 854 (1895).

Sydow, Mon. Ured. I., p. 563 (1903), p. 895 (1904).

Sacc. Syll. XIV., p. 295 (1899).

- O. Spermatogonia orange, numerous, aggregated, amphigenous, $150-170 \mu$ in diam.

Spermatia hyaline, globose to oval, $2\frac{1}{2}-3\frac{1}{2} \mu$ diam.

- I. Aecidia hypophyllous, crowded, often arranged in lines, greenish to yellowish-brown knob-like swellings before bursting; pseudoperidia white, cylindrical, with torn edges, average 630μ diam.

Aecidiospores orange-yellow, minutely warted, variously shaped, globose to ovate or mussel-shaped, $27-39 \times 22-25 \mu$.

- II. Uredosori amphigenous, soon naked, bullate, orange-red, generally orbicular, $1-1\frac{1}{2}$ mm. diam.

Uredospores orange-yellow, ellipsoid to ovoid, strongly echinulate, $27-37 \times 22-25 \mu$, average $31 \times 24 \mu$.

- III. Teleutosori amphigenous, black, compact, bullate, orbicular, irregular or elongated, scattered, covered by epidermis for some time, then erumpent.

Teleutospores golden-brown to chestnut-brown, elliptical to oblong, usually rounded at both ends, slightly constricted at septum, smooth, $40-60 \times 25-36 \mu$, average $50 \times 30 \mu$; pedicel hyaline, stout, persistent, up to 80μ long.

- X. Mesospores similarly coloured to teleutospores, ellipsoid or elongated, thickened at apex, $35-54 \times 25-29 \mu$.

On leaves and stems of *Tetragonia implexicoma* Hook. f.

Victoria.—On the coast at Sandringham, Beaumaris, Flinders, Portland, &c., all the year round.

Tasmania—Hobart, about rocks, Aug., 1897, I., II., III. (Rodway').

All the stages are usually very plentiful in the month of August.

The spermatogonia precede or accompany the aecidia on upper and under surface of the leaves, are flask-shaped and the neck projects slightly between the watery vesicles which stud the surface of the leaf. They often form

large, orange, blister-like clusters quite conspicuous against the green of the leaf, and the rust-devouring *Diplosis* was frequently met with there and probably scatters the spermatia.

The aecidia are usually swarming with the *Diplosis*, dipping into them as an insect inserts its proboscis into a flower, and sometimes it is entirely inside the cups. The larvae are invariably coated with the aecidiospores. Occur August to October and subsequently.

Uredospores just beginning to appear in October, and the *Diplosis* was also found on the sori.

Teleutospores are scanty in October, and they occur on the same leaves as uredospores.

The uredo and teleutosori are often associated together in the same cluster, and the three spore-forms may all occur on one leaf.

(Plate XI., Figs. 88, 89.)

POLYGONACEAE.

Rumex.

105. *Puccinia ludwigii* Tepp.

Tepper, Bot. Centralb., XLIII., p. 6 (1890).

Cooke, Handb. Austr. Fung., p. 336 (1892).

Sydow, Mon. Ured. I., p. 581 (1903).

Sacc. Syll. XI., p. 196 (1895).

II., III. Sori minute, circular, irregularly scattered or aggregated into small groups, soon naked and girt by the ruptured epidermis, on both surfaces of leaf, up to $\frac{1}{2}$ mm. diam.

II. Uredospores sub-globose to ovate, very finely echinulate, pale yellowish-brown, $22-28 \times 16-20 \mu$, or $19-22 \mu$ diam.

III. Teleutospores at first intermixed with uredospores, oblong to ellipsoid, rounded at both ends, very coarsely warted, slightly constricted at septum, not thickened at apex but generally with hyaline apiculus, sometimes three or four celled, dark brown, $30-40 \times 20-25 \mu$, average $32 \times 21 \mu$; pedicel short, hyaline, deciduous.

X. Mesospores similarly coloured to teleutospores, warted and with hyaline apiculus, oval, with short hyaline pedicel, $28-31 \times 18-23 \mu$.

On leaves of *Rumex brownii* Campd.

Victoria—Coromby, Oct., 1889 (Tepper). Shepparton, on river flats, Nov., 1895 (Robinson). Flinders, Jan. Murrumbidgee Ranges, Dec. Killara, March. Myrniong, Aug.

Queensland—Ennogera (Bancroft). Brisbane, Sept., 1886 (Bailey⁴).

Tasmania—Devonport, January, 1906 (Robinson).

On *Rumex flexuosus* Sol.

Victoria—Warracknabeal, Oct., 1903 (Reader)

I have had plenty of material of this species, both from Victoria and Queensland, as well as some of the original material from Ludwig, and examination shows that it is the same fungus in each case.

Mr. Bailey kindly supplied specimens from Queensland, and there is one in the National Herbarium, Melbourne, sent from Queensland to Dr. Cooke in 1886, and it is named in his own handwriting *P. rumicis* Lasch., = *P. acetosae* (Schum.) Koern. It has the same characters as the others, and on comparing it with *P. acetosae* from Syd. Ured. Exs., 1163, I find that it

differs in the more finely echinulate uredospores, but more particularly in the teleutospores, which are coarsely knobbed and altogether characteristic.

The introduced *Rumex crispus* and *R. acetosella* are exceedingly common weeds in Victoria, and may be seen growing alongside rusty *R. brownii*, but no rust has ever been detected on them.

R. brownii is a native species, and its parasite is evidently a native also.

The teleutospores are varied in shape, and three and four celled forms are met with. In the three-celled forms they may either be after the *Phragmidium* or *Triphragmium* type, and in the four-celled forms the upper third cell is vertically divided. Just as in *P. dichondrae* there is every gradation from the one to the four-celled spore.

Darlucula filum Cast., is common on the uredo and teleutosori.

(Plates XI., Figs. 90, 91, 92 ; XL., Fig. 300.)

Muehlenbeckia.

106. *Puccinia muehlenbeckiae* (Cooke) Syd.

Sydow, Mon. Ured. I., p. 566 (1903).

Sacc. Syll. IX., p. 299 (1891).

Puccinia rumicis-scutati (DC.) Wint. var. *muehlenbeckiae*
Cooke, Grev. XIX., p. 47 (1890), and Handb. Austr. Fung., p.
336 (1892).

- II. Uredosori hypophyllous, scattered or in irregular groups, sometimes circularly arranged, round or elliptic, girt by the torn epidermis, cinnamon-brown.

Uredospores yellowish-brown, ellipsoid or ovoid, echinulate, $24-32 \times 16-21 \mu$, average $28 \times 19 \mu$.

- III. Teleutosori similarly arranged to uredosori, but dark-brown.

Teleutospores at first intermixed with uredospores, clavate to oblong, dark-brown, constricted at septum, thickened at apex (up to 7μ), and rounded or obtuse, sometimes 3-4 celled, $32-45 \times 14-19 \mu$, occasionally reaching a length of 55μ , average $40 \times 18 \mu$; lower cell generally somewhat triangular; pedicel hyaline, generally persistent, up to 40μ long.

- X. Mesospores occasional, similarly coloured to teleutospores, ellipsoid to elongated oblong, smooth, rounded or conoid and thickened at apex (up to 5μ), $31-34 \times 12-18 \mu$.

On leaves of *Muehlenbeckia adpressa* Meissn.

Victoria—Brighton, May, 1894 (Morrison). Near Melbourne, Jan.—July. Cape Schanck, March, 1903 (C. French, jun.). Frankston, Feb., 1904 (Robinson). Sandringham, Sept., 1905, II., III.

On *Muehlenbeckia gracillima* Meissn.

Queensland—Gladfield (Gwyther) (Bailey¹⁵).
N.S. Wales—Kurrajong Heights (Musson).

Some of the mesospores show their connexion with teleutospores very clearly. In one instance two germ-pores were formed in the usual positions, while in another there was a slight notch on one side as if the beginning of a septum. They are evidently one-celled teleutospores, and have all their characters with the exception of the septum.

There were spots on the upper surface of the leaves with purplish-red margins, but these were due to gall-mites. The spores are of the general type of *P. rumicis-scutati*, but both kinds are somewhat smaller. I had a large amount of material to operate upon, and found the sori to be hypophyllous, although Cooke inadvertently describes them as epiphyllous. In a specimen of *P. rumicis-scutati*, from Syd. Ured. Exs. 25, the teleutospores are of a deep chestnut-brown, and attain a length of 57 μ . Sydow himself had not seen any specimens of the rust on *Muehlenbeckia*, but even from the brief description of Cooke he was right in making a species of it.

Darluca filum Cast., sometimes common on uredosori.

(Plate XI., Fig. 93.)

CHENOPODIACEAE.

Threlkeldia.

107. *Puccinia dielsiana* P. Henn.

Hennings, Hedw. XL., p. (95) (1901).

Sydow, Mon. Ured. I., p. 566 (1902).

Sacc. Syll. XVII., p. 361 (1905).

III. Teleutospores on stems, large, compact, bullate, erumpent, up to $\frac{3}{4}$ cm. long.

Teleutospores ellipsoid or oblong ellipsoid, generally rounded at both ends or obtuse and slightly thickened at apex (3–5 μ), smooth, very slightly constricted at septum, with granular contents, chestnut or dark-brown, 35–48 \times 18–28, average 38 \times 22 μ ; pedicel sub-hyaline, persistent, 80–120 \times 5–6 μ .

X. Mesospores occasional, ellipsoid to ovoid, coloured and thickened at apex like teleutospores, 34 \times 23 μ .

On stems of Chenopodiaceae—*Threlkeldia drupata* Diels.

W. Australia—Near Perth, 1900.

The teleutospore has occasionally a vertical septum, and in elongated slender specimens the breadth is reduced to 18 μ .

(Plate XI., Fig. 94.)

Kochia, *Enchylaena*.

108. *Puccinia kochiae* Mass.

Massee, Grev. XXII., p. 17 (1893).

Sydow, Mon. Ured. I., p. 565 (1903).

Sacc. Syll. XI., p. 196 (1895).

II., III. Sori amphigenous, discoid, plane, very compact, blackish-brown to black, often aggregated together, girt by the ruptured epidermis, up to 1 mm. diam.

II. Uredospores elliptical, golden-brown, decidedly echinulate, with numerous prominent germ-pores, as many as twelve on one face, 29–34 \times 18–25 μ , 32 \times 23 μ being very common.

III. Teleutospores densely packed, intermixed with uredospores, elliptic-oblong, rounded at both ends, or the apex with a slight indication of a papilla which is often oblique, perfectly smooth, chestnut-brown, hardly constricted at septum, epispore about 3 μ thick, 35–45 \times 22–29 μ , average 37 \times 25 μ ; pedicel tinted yellowish, persistent, 30–40 \times 6 μ , but may reach a length of 96 μ .

X. Mesospores few, similarly coloured to teleutospores, oval to flattened at apex, 28–35 \times 22–25 μ .

On leaves and stems of *Kochia sedifolia* F. v. M.; *Kochia villosa*, Lindl.; and *Enchylaena tomentosa* R. Br.

Victoria—Dimboola, Nov. and Dec. (Reader).

I have some of the material from Dimboola, portion of which was sent to Massee, and the golden-brown uredospores are seen along with the teleutospores. No uredospores were mentioned in the original description, a striking feature of which is the numerous germ-pores. The teleutospores have occasionally their septum lengthwise.

(Plate XI., Figs. 95, 96.)

CARYOPHYLLACEAE.

Stellaria.

109. *Puccinia arenariae* (Schum.) Schroet.

Schroeter, Pilz. Schles., p. 345 (1872).

Sydow, Mon. Ured., I., p. 553 (1903).

Sacc. Syll. VII., p. 683 (1888).

III. Teleutosori compact, pulvinate, roundish, scattered, often circinate, pale-brown to dark-brown.

Teleutospores fusoid or clavate, apex pointed or rounded, often thickened ($6-8\ \mu$), base rounded or attenuated, slightly constricted at septum, smooth, pale yellowish brown, $30-50 \times 14-20\ \mu$, average $35 \times 16\ \mu$, very rarely tricellular, $48 \times 16\ \mu$; pedicels hyaline, persistent, equal to or longer than the spores, $60-100\ \mu$.

X. Mesospores occasional, similarly coloured to teleutospores, obovoid or somewhat wedge-shaped, rounded or obtusely pointed or truncate at apex and thickened up to $6\ \mu$, generally resembling the upper cell of the teleutospore, with elongated pedicel, $22-29 \times 16-17\ \mu$.

On leaves and stems of *Stellaria media* Cyrill.

Victoria—Gellibrand, Feb., 1896 (Hill). Gembrook Ranges, April, 1904 (C. French, jun.).

The germ-tubes of the sporidiola of this species have been known to enter the stomata of *Dianthus barbatus* L., and it seems to be the only known case in the genus *Puccinia* of such germ-tubes entering stomata.

(Plate XII., Fig. 97.)

MALVACEAE.

Abutilon, Hibiscus.

110. *Puccinia heterospora* Berk. and Curt.

Berkeley and Curtis, Journ. Linn. Soc. X., p. 356 (1868).

Cooke, Handb. Austr. Fung., p. 338 (1892).

Sydow, Mon. Ured., I., p. 472 (1903).

Sacc. Syll. VII., p. 695 (1888).

III. Teleutosori minute, hypophyllous, soon naked, crowded in orbicular, glomerules, dark-brown, on determinate purplish or yellow spots.

Teleutospores very variable in size and shape, smooth, thick-walled and more deeply thickened at apex, dark chestnut-brown, elliptic or oblong, not or scarcely constricted at septum, occasionally divided vertically, $20-38 \times 17-28\ \mu$; pedicel hyaline, slender, elongated, three to four times as long as spore.

- X. Mesospores much more common than teleutospores, subglobose or elliptical, apex more thickened, pale-brown, 17–22 μ diam., or 25–32 \times 17–22 μ .

On leaves of *Abutilon crispum* Sweet, and *Hibiscus* sp. (Bailey¹⁶).

Queensland—Gulf of Carpentaria and St. George, Oct., 1885 (F. v. Mueller in National Herbarium).

On *Abutilon avicennae* Gaertn.

New South Wales—North-west part, Oct., 1887 (Bauerlen).

There are only relatively few bicellular spores present, and at first they were overlooked, the fungus being named *Uromyces pulcherrimus* B. and C., and *U. thwaitesii* B. and Br.

The so-called mesospores are probably of the nature of one-celled teleutospores, and this species may be regarded as a transition stage from the unicellular *Uromyces* to the bicellular *Puccinia*.

(Plate XII., Fig. 10I.)

Althaea, Lavatera, Malva, Plagianthus.

111. *Puccinia malvacearum* Mont.

Montagne in Gay's Hist. Chili VIII., p. 43 (1852).

Cooke, Handb. Austr. Fung., p. 338 (1892).

Sydow, Mon. Ured. I., p. 476 (1903).

Sacc. Syll. VII., p. 686 (1888).

- III. Teleutostori generally hypophyllous, brown to reddish-brown or orange, but grayish when spores are germinating, compact, round, pulvinate, elongate on the stems, scattered or crowded, seldom confluent, at first covered by epidermis, soon naked.

Teleutospores fusiform, attenuated at both ends, apex sometimes rounded, slightly constricted at septum or not at all, apical thickening slight, smooth, yellowish-brown, rarely tricellular, 35–75 \times 12–26 μ , average 50 \times 17 μ ; pedicels firm, long, persistent, occasionally septate, sometimes measuring 170 μ long.

- X. Mesospores occasional, same colour as teleutospores, somewhat fusiform, slightly thickened at apex, 40–45 \times 17–19 μ .

On all green parts of *Malva rotundifolia* L., *M. sylvestris* L., *Althaea rosea* Cav., *Lavatera plebeia* Sims, and *Plagianthus spicatus* Benth. Exceedingly common.

Victoria—(Berkeley²).

New South Wales—(Sacc. and Berl.¹).

Queensland—(Bailey⁷).

South Australia.

West Australia—(Morrison).

Tasmania—(Rodway¹).

The sori first appearing were carefully examined for any trace of accompanying spermogonia, but none were found. Spores occasionally 3-celled, and reaching a length of 77 μ .

This fungus, which was originally described by Montagne, has now overspread the earth and occurs on both wild and cultivated species of Malvaceous plants. Dr. Plowright⁵ states that he has a specimen in his herbarium from Melbourne, gathered as early as 1865 on *Malva sylvestris*.

Puccinia malvacearum is one of the commonest of rusts, and the different stages in the growth of the spore are well seen in this species. A group may be observed springing from a common hypha, and at first they are without septa, but soon a transverse septum is formed, and, although specially looked for, I have never seen a partial septum as recorded by Fischer⁵.

Germination occurs as soon as the spore is ripe, but some may hibernate. Occasionally the pedicel has a septum. Mr. French, Government Entomologist, has observed this rust on Hollyhocks in a nursery near Melbourne as early as 1857.

(Plate XII., Figs. 99, 100 ; Plate XV., Figs. 123-130 ; Plate F., Fig. 28.)

Plagianthus.

112. *Puccinia plagianthi* McAlp.

McAlpine, Proc. Roy. Soc. Vic. VII, N.S., p. 218 (1894).

Sydow, Mon. Ured. I., p. 480 (1902).

Sacc. Syll. XIV., p. 295 (1899).

III. Teleutosori hypophyllous, sparingly epiphyllous, scattered, pulverulent, soon naked, up to $1-1\frac{1}{2}$ mm.

Teleutospores golden-brown, oblong to clavate, rounded at apex, slightly attenuated towards base or rounded, slightly constricted at septum, very rarely three celled, epispore with reticulated markings, $38-50 \times 17-23 \mu$, average $41 \times 20 \mu$; pedicel hyaline, short, deciduous, but may attain a length of 60μ .

On leaves and flowers of *Plagianthus sidoides* Hook. Very common.

Tasmania—Mount Wellington, southern slope, Aug.—April (Rodway¹).

The spore is described as smooth by Sydow, but it is seen to be covered with a fine irregular network.

(Plate XII., Fig. 98.)

GERANIACEAE.

Geranium.

113. *Puccinia geranii-pilosii* McAlp.

II. Uredosori hypophyllous, chocolate-brown, scattered or sub-gregarious, orbicular, soon naked and surrounded by ruptured epidermis, compact, up to 1 mm. diam., often on purplish-red spots or portions of leaf becoming coloured.

Uredospores yellowish-brown, elliptical to obovate, echinulate, epispore slightly thickened at base, $25-30 \times 19-22 \mu$.

III. Teleutosori elongated, dark-brown to black, sometimes confluent, erumpent, compact, $1-1\frac{1}{2} \mu$ long, commonly on petiole.

Teleutospores at first intermixed with uredospores, oblong to oblong-clavate, chestnut-brown, smooth, slightly constricted at septum, sometimes short and stout and about as broad as long, $32-48 \times 22-32 \mu$, average $36 \times 25 \mu$; upper cell rounded at apex, not or slightly thickened; lower cell rounded at base or occasionally slightly tapering; germ-pore generally indicated at apex by a paler groove; pedicel hyaline, deciduous, elongated, up to 80μ long.

- X. Mesospores occasional, similarly coloured, subglobose, thickened at apex, 25–26 μ diam.

On living leaves of *Geranium pilosum* Sol.

Victoria—Killara, Nov., 1902, II., March, 1903, II., III. (Robinson).

New South Wales—Richmond (Musson).

Occasionally a teleutospore occurs in which the septum is vertical as in *Diorchidium*.

In the recorded species of *Puccinia* on *Geranium* there are only teleutospores with the exception of *P. callaguensis* Neger, on leaves of *Geranium berterianum* Colla, in Chili.

It differs from this species however in the teleutospores being smooth and not minutely verrucose, and in the elongated pedicel.

The host-plant is variously named. It is found in all the Australian States, and was called *G. pilosum* by Solander.

In the *Index Kewensis* it is given as a synonym of *G. dissectum*, but the late Baron von Mueller used the name of *G. pilosum*, considering it "more exact than that of *G. carolinianum* and *G. dissectum*."

F. M. Bailey, in his *Queensland Flora*, divides *G. dissectum* into two principal races, one of which is *pilosum*.

The species of *Puccinia* found upon it is new, and while it is not customary to determine a host-plant from the species of rust found upon it, still in this instance it lends probability to the view that we are here dealing with an indigenous form of *Geranium*, differing from *G. dissectum*. For this reason I have not followed the *Index Kewensis* in naming the host.

(Plate XII., Figs. 103, 104.)

Pelargonium.

114. *Puccinia morrisoni* McAlp.

- I. Aecidia amphigenous, delicate, minute, orange, circinate, either alone or accompanied by teleutospores; pseudoperidia with expanded and lobed margin; peridial cells subquadrate to oblong with striated margin, and punctate all over, firmly united, 28–32 \times 16–22 μ .

Aecidiospores pale orange, finely echinulate, elliptic to subquadrate, 19–22 \times 16 μ , or 18–19 μ diam.

- II. Uredosori mostly on under surface of leaf, round, small, brownish, pulverulent, solitary or arranged in confluent groups.

Uredospores subglobose to ellipsoid, yellowish brown, echinulate, 22–24 μ diam., or 22–27 \times 19–22 μ .

- III. Teleutosori intermixed, solitary or arranged in small confluent groups, generally round, black, compact, surrounded by ruptured epidermis.

Teleutospores chestnut brown, clavate, constricted at septum, smooth, often obliquely pointed or rounded and thickened at apex (up to 9 μ), 33–64 \times 19–25 μ , average 45 \times 22 μ ; lower cell usually paler in colour and attenuated towards base; pedicels tinted, generally short, persistent, up to 38 μ long by 6–9 μ broad.

- X. Mesospores coloured like teleutospores, oblong to oval, bluntly pointed and thickened at apex, 33–38 \times 16–20 μ .

On stems, leaf-stalks and leaves of *Pelargonium australe* Jacq.

Victoria—1892, II., III. (Morrison). Phillip Island, Jan., 1900, II., III. Murramurrangbong Ranges, Dec., 1903, I., II., III. (Robinson).

Tasmania—Devonport, Jan., 1906 (Robinson).

The only locality where aecidia were found was the Murramurrangbong Ranges.

It differs from *P. geranii* Corda, to which this species was referred by Cooke in Grevillea, XXI., p. 39, in the uredospores being nearly twice as large, and in the much longer and broader teleutospores.

There are two species of *Puccinia* already recorded upon the genus *Pelargonium* from S. Africa, viz., *P. pelargonii* (Thuem.) Syd., and *P. granularis* Kalch. and Cooke.

In *P. pelargonii* the aecidia are hypophyllous, and not amphigenous, and the teleutospores are rather shorter and narrower. In *P. granularis* there are no aecidia.

(Plate XII., Fig. 102 ; Plate F., Fig. 29.)

RUTACEAE.

Boronia.

115. *Puccinia boroniae* P. Henn.

Hennings, Hedw. XLII., p. (73) (1903).

Sydow, Mon. Ured. I., p. 891 (1904).

Sacc. Syll. XVII., p. 351 (1905).

- III. Teleutosori on branches, erumpent, pulvinate, tuberculate, dark cinnamon, compact, confluent lengthwise up to 2 cm. long, surrounded at base by the ruptured epidermis.

Teleutospores ellipsoid to ovate, oblong, brown, smooth, rounded or bluntly pointed at apex and slightly thickened (up to 5 μ), generally rounded at base, 28–40 \times 16–21 μ , average 35 \times 20 μ , occasionally 3-celled and elongated, 52 \times 25 μ ; pedicel hyaline to yellowish, persistent, up to 120 μ long.

- X. Mesospores common, similarly coloured to teleutospores, ellipsoid to obovoid, rounded or bluntly pointed at apex and slightly thickened, 30–34 \times 17–18 μ .

On *Boronia spinescens* Benth.

West Australia—Avon, Oct., 1903 (Diels).

A very interesting Leptopuccinia which projects from the cortex of the branches in thick, often confluent pustules, and partially surrounds them.

A specimen was kindly forwarded by Hennings, and the mesospores were observed which are not given in the original description. The size of the teleutospores, as given by Hennings, is 20–32 \times 15–18 μ . by Sydow, 22–35 \times 16–19 μ , and I have made the average 35 \times 20 μ , my measurements being corroborated by those in the photographs, which are also about 35 \times 20 μ .

(Plate XIII., Fig. 107.)

Correa.

116. *Puccinia correae* McAlp.

McAlpine, Proc. Roy. Soc. Vict. VII., N.S., p. 215 (1894).

Sydow, Mon. Ured. I., p. 462 (1903).

Sacc. Syll. XIV., p. 297 (1899).

- III. Teleutosori hypophyllous, cushion-shaped, circular or interruptedly circular, dirty brown, scattered, soon naked.

Teleutospores yellowish-grey, long-stalked, elongated fusoid, constricted at septum, $44-60 \times 17-20 \mu$, average $50 \times 18 \mu$; upper cell elongated, tapering and rounded at apex; lower cell tapering towards base; pedicel light grey, several times as long as teleutospore.

- X. Mesospores similarly coloured and stalked, ovoid, with truncated apex, $25-28 \times 16-19 \mu$.

On leaves of *Correa lawrenciana* Hook.

Tasmania—Mount Wellington, Dec. Coast near Trial Harbour, Jan., 1894 (Rodway¹).

The sori stand out very distinctly from the cinnamon-brown under surface of the leaves, causing corresponding circular depressions on upper surface, of a yellowish-green colour. Although the plant is very common, the rust was very rare.

(Plate XIII., Fig. 106.)

Eriostemon.

117. *Puccinia eriostemonis* McAlp.

- III. Teleutosori hyphophyllous, dark-orange, ellipsoid, somewhat circularly arranged, erumpent, surrounded by ruptured epidermis, up to 2 mm. long.

Teleutospores clavate to ellipsoid, with finely granular orange contents, compact, smooth, generally rounded at apex, sometimes pointed, slightly thickened, usually tapering towards base, constricted at septum, $30-45 \times 15-18 \mu$, average $32 \times 16 \mu$; pedicel persistent, hyaline, elongated, up to 125μ long by $3-5\frac{1}{2} \mu$ broad.

- X. Mesospores occasional, similarly coloured to teleutospores, ellipsoid, thickened and bluntly pointed at apex, $30-32 \times 13-16 \mu$.

On leaves of *Eriostemon myoporoides* DC.

Victoria—Mt. Bernard, Nov., 1903 (C. French, jr.). Alps, near Bright, Dec., 1904 (C. French, jr.)

Occasionally a spore occurs in which the septum is longitudinal.

This species differs from *P. correae* McAlp., in the sori being orange instead of brown, the spores are smaller, with finely granular orange contents, and the epispore rather thicker.

(Plate XIII., Fig. 105.)

TREMANDRACEAE.

Tremandra.

118. *Puccinia pritzeliana* P. Henn.

Hennings, Hedw. XL., p. (95) (1901).

Sydow, Mon. Ured. I., p. 460 (1902).

Sacc. Syll. XVII., p. 350 (1905).

- III. Teleutosori hypophyllous, on round brown spots, frequently with purplish margin, scattered or in orbicular groups, pulvinate, cinnamon-brown, $\frac{1}{2}-1\frac{1}{2}$ mm. diam.

Teleutospores oblong or oblong clavate, obtusely rounded at apex, which may or may not be thickened, sometimes two-papillate, or occasionally somewhat crested, slightly constricted at septum, generally rounded at base, yellowish, smooth, $40-60 \times 15-25 \mu$, average $48 \times 20 \mu$; pedicels hyaline, persistent, up to 150μ long.

- X. Mesospores rare, similarly coloured to teleutospores, somewhat oblong and bluntly apiculate at apex, $43 \times 28 \mu$.

On living leaves of *Tremandra stelligera* R. Br.

West Australia—Near Perth, Oct., 1900 (Pritzel).

Quite distinct from *P. tremandrae* Berk. from Ceylon.

(Plate XIII., Fig. 108.)

VIOLACEAE.

Viola.

119. *Puccinia hederaceae* McAlp.

- O. Spermogonia arranged in small or large groups, crowded, honey-coloured.

Spermatia hyaline, globose, minute, $2\frac{1}{2}-3 \mu$ diam.

- I. Aecidia on all green parts of the plant and flowers, on both surfaces of leaf but mostly hypophyllous, disposed in circular or irregular groups; pseudoperidia flat, about $\frac{1}{2}$ mm. diam. with white, torn, revolute edges.

Aecidiospores subglobose to shortly elliptical, finely warted, orange-yellow, about 16μ diam., or $16-19 \times 12-14 \mu$.

- II. Uredosori minute, brown, roundish, erumpent, scattered, soon naked, on both surfaces of leaf.

Uredospores subglobose or shortly elliptical, golden-brown, strongly echinulate, 2-3 germ-pores on one face, $25-29 \times 18-22 \mu$, average $25 \times 21 \mu$ and $22-25 \mu$ diam.

- III. Teleutostori minute, black, roundish, erumpent, usually surrounded by ruptured epidermis, pulverulent.

Teleutospores at first intermixed with uredospores, elliptic or oblong, rounded at both ends or slightly attenuated towards base, hardly constricted at septum, distinctly warted all over but prominently on upper cell, chestnut-brown, usually with hyaline apiculus, occasionally unicellular, $29-49 \times 17-22 \mu$, average $35 \times 19 \mu$; pedicel hyaline, deciduous, short.

On living leaves of *Viola hederacea* Labill.

Victoria—Near Melbourne, Oct., Nov., and Dec., 1885, 1886 (Reader). Wandin, Dec., 1895. Murramurrangbong Ranges, Nov., 1902, Dec., 1903, Jan., 1905 (Robinson). Mt. Blackwood, Dec., 1902. Alps, near Bright, Dec., 1904 (C. French, jun.)

Tasmania—Cascade Rivulet, Dec., 1892 (Rodway¹). Mt. Dromedary, Dec., 1894 (Rodway¹). Devonport, Jan., 1906 (Robinson).

On *V. betonicifolia* Sm.

Tasmania—Ben Nevis, April, 1896 (Rodway).

New South Wales—Monga (Bauerlen), recorded as *Aecidium violae* Schum. by Baker¹. Richmond (Musson).

Victoria—Murramurrangbong Ranges, Nov., 1902 (Robinson).

A few one-celled teleutospores were observed among the ordinary teleutospores, which they resembled in every respect except size and shape, even having the germ-pore quite distinct beneath the apex, ellipsoid, with small hyaline apiculus, $25-26 \times 20 \mu$.

Aecidium violae Schum. is given by Dr. Cooke in his Handbook as occurring on Victorian native violets, but it is the aecidium belonging to *P. hederaceae* McAlp.

This species was at first determined as *P. aegra* Grove by Winter², but on comparing the two species they are seen to be decidedly different.

It is closely allied to *P. violae* (Schum.) DC., but differs in the teleutospores being larger, and warted all over. Specimens of *P. violae* were examined from Syd. Ured. Exs., No. 286, on *Viola arenaria*, and from Kellerman's Ohio Fungi, No. 96, on *Viola blanda*. The average size of the teleutospores was found to be $22-32 \times 16-19 \mu$, and were generally smooth, although occasionally a little warted.

P. aegra Grove, is recorded by Cooke for Australia; but all the specimens I have met with, including part of the same collection of material forwarded to Dr. Cooke, have echinulate aecidiospores, and warted teleutospores, and are therefore not this species.

(Plate XIII., Figs. 109-112; Plate E., Figs. 24, 25.)

CRUCIFERAE.

120. *Puccinia cruciferae* McAlp.

- I. Aecidia amphigenous and on stems, in irregular clusters or circinate, large, cup-shaped, $\frac{1}{3}-\frac{1}{2}$ mm. diam.; pseudoperidia with whitish edges, crenulate, slightly revolute; pseudoperidial cells ovoid or oblong, punctulate all over, with striated margin, average 25μ long.

Aecidiospores orange, subglobose, finely echinulate, $14-16 \mu$ diam.

- III. Teleutostori on upper surface of basal leaves, associated with aecidia, a few together, round, bullate, compact, covered at first by raised grey epidermis, which splits irregularly, up to 1 mm. diam.

Teleutospores black in mass, dark chestnut-brown individually, oblong to clavate, smooth, slightly constricted at septum, bluntly pointed, rounded or truncate at apex and thickened up to 9μ , tapering slightly or rounded at base, $37-62 \times 18-25 \mu$; pedicels usually slightly tinted towards apex, persistent, up to 50μ long and 10μ broad.

- X. Mesospores common, similarly coloured to, or paler than, teleutospores, variously shaped, ellipsoid, oblong or ovate, pointed, rounded, or truncate at apex, and thickened up to 7μ , $25-34 \times 14-20 \mu$, with pedicels equally long and similar to those of teleutospores.

On Cruciferous plant.

New South Wales—Guntawang (Hamilton).

It differs from *P. cruciferarum* Rud., in having aecidia, and from *P. barbareae* Cooke, in which the teleutospores are broadly lanceolate and considerably narrower.

This is a portion of the original material which was named *Aecidium barbareae* in Cooke's *Handbook of Australian Fungi* but, on closely examining it, teleutosori were found. The host-plant is not *Barbarea vulgaris* R. Br., which is the only species of that genus in Australia.

(Plate XXX., Fig. 266.)

DILLENIACEAE.

Hibbertia.

121. *Puccinia hibbertiae* McAlp.

III. Teleutosori ruddy-brown to black, compact, soon naked, up to 1 mm. diam., on under surface of leaves.

Teleutospores pale yellowish-brown, oblong to somewhat clavate, smooth, constricted at septum, $35-41 \times 18-21 \mu$; upper cell rounded at apex to somewhat conical, usually thickened (up to 6μ); lower cell generally rounded at base, sometimes slightly attenuated; pedicel hyaline, persistent, elongated, slender, $120-150 \mu$ long.

X. Mesospores occasional, similarly coloured to teleutospores, generally fusiform and thickened at apex, sometimes elongated oblong, $33-35 \times 12-16 \mu$.

On *Hibbertia sericea* Benth.

Victoria—Cheltenham, July, 1904 (Robinson). Oakleigh, Sept., 1904.

The small size of the leaf together with the scanty sori render this species easily overlooked. The teleutospores are often noticed germinating *in situ*.

(Plate XXX., Fig. 265.)

PHRAGMIDIUM Link.

This genus occurs exclusively on the Rose family, and of the 46 species recorded by Dietel¹³, only four are found in Australia. They are all autoecious, and in some instances spermogonia accompany aecidia. The aecidia are of the caeoma type, but paraphyses take the place of a peridium. The species, (*P. barnardi*) on the native raspberry (*Rubus parvifolius*) does considerable damage, and the imported species—*P. subcorticium*—is spreading extensively on the sweetbrier.

General Characters.—Spermogonia flattened or slightly raised, generally arranged in concentric circles.

Aecidia after caeoma type, surrounded by a dense crown of inwardly-curved paraphyses.

Caeomospores with numerous distinct germ-pores distributed over the entire surface.

Uredosori likewise surrounded by paraphyses.

Uredospores solitary on basidia, with numerous germ-pores.

Teleutospores separate, pedicellate, consisting of from three to ten, superimposed cells, the uppermost of which has one to three germ-pores, the others about three to four each, placed laterally.

Sporidiola spherical.

Australian species, 4.

ROSACEAE.

Rubus.122. *Phragmidium barnardi* Plow. and Wint.

Winter, Rev. Myc., VIII., p. 208 (1886).

Cooke, Handb. Austr. Fung., p. 339 (1892).

Sacc. Syll. VII., p. 746 (1888).

- O. Spermogonia on numerous, minute, discoloured patches on upper surface of leaf, appearing as ruby coloured, minute, blister-like puckered swellings, with round central pore, and arranged in small concentric circles.

Spermatia golden-yellow in mass, hyaline individually, minute, narrowly ellipsoid, embedded in mucilage, $4-6 \times 2\frac{1}{2}-3 \mu$.

- II. Uredosori scattered on under surface of leaf, corresponding to spots on upper surface, very irregular in outline, ochraceous, also sparingly on upper surface of leaf, usually on veins, ellipsoid to elongated ellipsoid, surrounded by ruptured epidermis, and pale in colour.

Uredospores globose or ellipsoid, epispore thick, warty, dark yellow, $17-19 \mu$ diam. or $21-26 \times 17-19 \mu$; paraphyses surrounding them, at first colourless, finally yellowish-brown, variously and peculiarly shaped, generally curved and pointed at apex, $30-40 \times 9-12 \mu$.

- III. Teleutosori scattered or gregarious, minute, dark brown, not rarely confluent, pulverulent.

Teleutospores at first intermixed with uredospores, golden-brown, cylindrical, equal, rounded at apex, sometimes with a short, hyaline, conoid apiculus, 6-9 septate (8 very common), constricted at septa, smooth, usually two germ-pores on one face in each cell, or three altogether, $60-115 \times 23-28 \mu$; pedicels hyaline, cylindrical, or a little inflated, sometimes uniseptate towards base, very long, up to $207 \times 10-19 \mu$.

On living leaves of Native Raspberry (*Rubus parvifolius* L.).

Victoria—Alps near Bright, Arthur's Creek, Flinders, Killara, Murramurrangbong Ranges, Myrniong, near Melbourne, Phillip Island, Seymour, &c.

South Australia—Mount Lofty (Tepper²).

Tasmania—Huonville, Jan., 1892 (Rodway¹). Mount Wellington, Jan., 1892 (Rodway).

As early as 1886 this species was determined by Plowright and Winter from specimens sent by that veteran microscopist, Mr. F. Barnard, Kew, Victoria.

The teleutospores occur on the same leaves as the uredospores, and they germinate on the living plant immediately on ripening. The germ-pores in each cell may be seen very clear and distinct. There are two in each seen on one face, situated laterally and immediately below each of the septa, and by means of careful focussing it can be seen that there is one behind, thus making *three* in each cell. In the apical cell there are also two just above the septum, and a third may also be seen as in the other cells.

Dietel¹ remarks that there is only one germ-pore in each cell of this species, but, as indicated above, three can usually be seen with such distinctness that they are capable of being photographed, as shown in the Figures.

Teleutospores were found germinating on the living plant. The promycelium was stout and consisted of four cells with a basal cell, the contents being greyish like the sporidiola. The sporidiola are subglobose and 7–8 μ diam.

This fungus does considerable damage to the native raspberry, causing the leaves to fall prematurely.

(Plate XXVI., Figs. 234, 235 ; Plate I., Fig. 38.)

Rubus.

123. *Phragmidium longissimum* Thuem.

Thuemen, Flora, p. 379 (1875).

Cooke, Handb. Austr. Fung., p. 340 (1892).

Sacc. Syll. VII., p. 750 (1888).

Hamaspora longissima Koern. Hedw. XVI., p. 23 (1877).

- II. Uredosori hypophyllous, scattered or gregarious, or even confluent, clear orange, surrounded by a dense layer of paraphyses.

Uredospores globose or obovate or shortly elliptical, pale yellow, with thick epispore, 16 μ diam.

- III. Teleutospores on both surfaces of leaf, agglutinated in long filaments up to 6 mm. long, rather gelatinous when moist, but when dry twisted up and silky-fibrillose, 4 to 6 celled, commonly 4-celled, yellowish to cream-coloured, containing granular protoplasm, cylindric acuminate, with apex sharply pointed and hyaline, 110–190 \times 12–15 μ ; pedicel hyaline, tapering gradually towards base to a fine point, hollow, just slightly narrower than spore, 10–12 μ broad, and reaching a length of 500 μ .

On leaves of *Rubus moluccanus* L.

Queensland—Eudlo Creek (Bailey⁹).

This species was first observed on *Rubus* in S. Africa, and destroys the foliage of one of the blackberries indigenous to Queensland. Bailey kindly sent me specimens in which the teleutospores are germinating *in situ*.

Scattered over the leaves are groups of silky-looking twisted filaments, and on being teased out are seen under the microscope to consist of innumerable spores with their long pedicels inextricably blended.

The germinating spores are seen to have one germ pore in each cell, and the order of germination is basipetal. The promycelial branches are stout, elongated, and transversely septate, and they may either all arise on one side of the spore, or partly only on one side. The promycelial spores are subglobose, finely warted and 9–10 μ diam.

The teleutospores were very commonly 140 μ long, and one 6-celled individual attained a length of 190 μ . As might be expected in such a long and variously septate spore there is considerable difference in the lengths recorded. It was originally given as 200–240 μ , then Masee reduced it to 70–130 μ , and in the Queensland specimens I have found it to be 110–190 μ . The stalks are excessively long, and they may reach a length of 500 μ or more.

The teleutospores agree with those of *Phragmidium* in being three or more transversely septate, but they are agglutinated together into a gelatinous cylindrical filamentous mass, and each cell only possesses one germ pore.

Massee³ from an examination of fresh material comes to the conclusion that it is not a *Phragmidium* nor a *Hamasporea*, although he does not undertake the responsibility of forming a new genus.

Dietel^{8, 10}, on the other hand, considers that there are no substantial grounds for separating this species from *Phragmidium*, although he recognises a resemblance to *Gymnosporangium* in the arrangement and structure of the teleutospores.

(Plate XXXI., Fig. 272.)

Acaena.

124. *Phragmidium potentillae* (Pers.) Karst.

Karsten, Fung. Fenn., No 94 (1868).

Winter, Rev. Myc. VIII., p. 208 (1886).

Cooke, Handb. Austr. Fung., p. 339 (1892).

Sacc. Syll. VII., p. 743 (1888).

- [I. Caemata arranged in circular groups, often confluent, orange yellow to reddish.

Caemospores crowded in a short series, globose, ovate or ellipsoid, echinulate, $17-24 \times 14-19 \mu$.]

- II. Uredosori hypophyllous, orange-red, roundish, scattered or gregarious, often confluent, surrounded by a crown of club-shaped paraphyses.

Uredospores spherical, elliptical or ovate, yellowish, echinulate, $17-24 \times 14-20 \mu$, average $18 \times 15 \mu$.

- [III. Teleutosori orbicular, black, pulvinate, minute.

Teleutospores oblong, 2-6 septate (usually 3-5), slightly constricted, obtuse, or obtusely apiculate above, slightly attenuated below, smooth, yellowish-brown, $50-70 \times 20-22 \mu$; pedicels colourless, firm, $100-150 \mu$ long.]

On living leaves of *Acaena sanguisorba* Vahl.

Victoria—Near Melbourne, 1886 (Reader). (Winter.²)

On *Acaena ovina* A. Cunn.

S. Australia—Sept., 1898 (Quinn).

The specimen from Victoria was originally determined by Winter, and portion of the same material, kindly supplied by Reader, shows only uredospores.

Darluca filum Cast. is plentiful on some of the sori.

Rosa.

125. *Phragmidium subcorticium* (Schrank) Winter.

Winter, Die Pilze I., p. 228 (1884).

Cooke, Handb. Austr. Fung., p. 339 (1892).

Sacc. Syll. VII., p. 746 (1888).

- I. Caemata forming large dense swellings on stems, leaf-stalks, and fruits, and lesser swellings on lower surface of leaves, effused, generally confluent, bright orange, with club-shaped paraphyses.

Caemospores ellipsoid to ovoid, echinulate, epispore hyaline, and contents orange, $25-29 \times 14-20 \mu$.

- II. Uredosori hypophyllous, on yellow spots, yellowish red, minute, orbicular, scattered or crowded, with tubular paraphyses slightly swollen towards apex, and not particularly club-shaped.

Uredospores ellipsoid, ovoid or piriform, finely echinulate, reddish orange, 4-6 germ-pores on one face, $22-29 \times 16-20 \mu$.

- III. Teleutosori hypophyllous, minute, scattered or crowded, black, readily detachable.

Teleutospores oblong, dark-brown, warted, obtuse at the apex with a colourless apiculus, 7-8 celled, with 2-3 germ-pores on one face in each cell, $75-102 \times 32-36 \mu$; pedicel hyaline, except pale-brown towards apex, expanded in the lower half, 100-150 μ long and broadened up to 22 μ .

On *Rosa rubiginosa* L., *R. canina* L., and *R. laxa* Retz.

Victoria—Pascoe Vale, Oct., 1898 (Cronin). Ferntree Gully, April, 1899 (Hill). Brighton, Nov., 1901, Aug., 1903, June, Oct. and Dec., 1904, March, 1905, II.

S. Australia—Third Creek Garden, Mt. Lofty Range, Nov., 1899 (Tepper). Nov., 1900 (Agricultural Bureau), II., III.

Tasmania—Launceston, Oct., 1902 (Littler). Hobart, Apr., 1903, II., III. (Rodway).

This species is now very common around Melbourne, particularly on the sweetbrier (*R. rubiginosa*). It has also become a pest in the nurseries, causing considerable damage to the dog-rose stocks (*R. canina*). Seedlings are attacked very severely in a favorable season and killed outright. This rust occurs in some of its stages, practically all the year round, but is less common in midsummer. The uredospores resemble the caeciospores in their size and shape, but may be distinguished by their long stalks (up to 56 μ) and their germ-pores.

The mycelium of the caecoma may winter in the stems, so that by means of cuttings the disease was probably introduced into Australia. It may also have been introduced with the seeds of the sweetbrier, for that was among the first European plants to be imported into Tasmania and New South Wales, and used as hedges.

(Plate XXVI., Figs. 229-233; Plate I., Fig., 37.)

CRONARTIUM Fries.

Only one species of this genus is known here, and it occurs rather commonly on certain leguminous plants. So far teleutospores only have been found. This genus produces uredo and teleutospores on one host plant, and the aecidial stage on another, but the latter has not yet been found in Australia. In Europe there is a bladder-rust on the bark of *Pinus sylvestris*, and this has been proved to be the aecidial stage of *Cronartium asclepiadeum* (Willd.) Fr. As in so many other similar cases, this stage was considered to be an independent form, and named *Peridermium cornui* Rostr. and Kleb.

General characters.—Spermogonia truncate to conoid.

Aecidia with bladder-like, irregularly opening pseudoperidia (*Peridermium*).

Aecidiospores without germ-pores, separated by distinct intermediate cells, epispore always more or less regularly warty reticulated.

Uredo-layer included in hemispherical pseudoperidium, which opens at apex by a narrow pore.

Uredospores echinulate, without germ-pores.

Teleutospores unicellular, united into a cylindrical, vertical, horny column, germinating *in situ*, surrounded at base by the uredospores.

Sporidiola subglobose, hyaline.

Australian species, 1.

LEGUMINOSAE.

Jacksonia, &c.

126. *Cronartium jacksoniae* P. Henn.

P. Hennings, Hedw. XL, p. 127 (1901).

- O. Spermogonia honey-coloured, crowded or in lines, circular, flattened, on branches and lower surface of leaves.

Spermata hyaline, ovoid to ellipsoid, $5-6 \times 2\frac{1}{2}-3 \mu$.

- III. Teleutostori forming ruddy-brown, straight or curved, simple columns, crowded, $2-2\frac{1}{2}$ mm. high, with blunt apex, on young and swollen branches.

Teleutospores ruddy-brown in mass, more or less colourless individually, elongated, generally somewhat tapering towards each end, with large vacuole, cylindrical to fusiform, contents granular, $40-50 \times 8-10 \mu$; teleutospores germinate at once and produce promycelia with promycelial spores, which are hyaline, globose, and average about $6-7 \mu$ diam.

On *Jacksonia scoparia* R. Br.

Queensland—Darling Downs (Law), (Bailey²). Near Brisbane (Bailey⁴).

On *Platylobium formosum* Sm.

Victoria—Murrumbidgee Ranges, Nov. and Dec., 1902-3 (Robinson).

On *Gompholobium latifolium* Sm.

Victoria—Murrumbidgee Ranges, Dec., 1903 (Robinson).

On *Bossiaea cinerea* R. Br.

Victoria—Near Melbourne, Nov., 1904 (Robinson).

Tasmania—Bellerive, Dec., 1905 (Rodway).

On *Aotus villosa* Sm.

Victoria — Near Melbourne, Sept., O. Nov., 1904, III. (Robinson).

It deforms the shoots of the plant on which it grows, causing malformation of branches and multiplication of shoots (witches' brooms), and is so common in some parts that the great majority of the shrubs are attacked.

The spermogonia were only found on *Aotus* and before the appearance of the teleutospores, but the multiplication and deformation of the shoots had already been produced. On *Bossiaea cinerea* on one occasion *Aecidium eburneum* McAlp. was found on the same plant near Melbourne.

The horn-like aggregation of teleutospores varies in length from 1-2 mm. on *Aotus* and *Bossiaea* to $2-2\frac{1}{2}$ mm. in *Platylobium* and *Gompholobium*.

The original specimen on *Jacksonia scoparia* in the National Herbarium, Melbourne, is given as a variety of *C. asclepiadeum* (Willd.) Fr., in Berkeley's handwriting, and is recorded in the Journal of the Linnean Society, p. 174 (1883), with the remark that the only specimens are in a young state. The same species was subsequently found by G. H. Robinson very plentifully in Victoria on various species of Leguminous plants, and the germinating teleutospores were clearly seen.

Considering its occurrence on indigenous Leguminous plants, together with the narrower teleutospores and colourless promycelial spores, as compared with *C. asclepiadeum*, I considered it a new species and had named it *C. leguminum*. But I find that Hennings in a footnote in Hedwigia XL., p. 127, states that the form occurring on *Jacksonia* is specifically distinct from *C. asclepiadeum*, and had better be named *C. jacksoniae*, the name now adopted.

(Plates XXXVII., XXXVIII.)

MELAMPSORA Castagne.

In this genus there are both heteroecious and autoecious species, but only the latter occur in Australia. The two species known are on native plants, but they also occur in Britain on the same genera. They only possess uredo and teleutospores, but the three spore-forms may occur on the same host—(*M. amygdalinae* Kleb.), or only aecidia and teleutospores (*M. saxifragarum* (DC.) Schroet.).

The teleutospores form flat irregular crusts, and are united to each other like the cells of a honeycomb.

Rostrup first pointed out in 1883 the connection between this genus and *Caeoma* species, and now the relation between a number has been proved by cultures.

General description.—Spermogonia forming a minute, hemispherical, flattened stratum, often subcuticular, otherwise subepidermal.

Aecidia after the caeoma type, destitute of a pseudoperidium, usually without paraphyses, pustular.

Uredospores usually without distinct germ-pores, included in more or less developed peridia.

Teleutospores unicellular, rarely transversely divided, coalescing in a plane, firm, black or dark-brown stratum. Sporidiola globose, yellow, then orange.

Australian species, 2.

HYPERICACEAE.

Hypericum.

127. *Melampsora hypericorum* (DC.) Schroet.

Schroeter, Brand und Rost., p. 26 (1872).

Sacc. Syll. VII., p. 591 (1888).

- II. Uredosori mostly hypophyllous, scattered or subgregarious, at first bright orange, becoming pale, pulverulent, small, up to $\frac{1}{2}$ mm. diam, erumpent and surrounded by the ruptured epidermis.

Uredospores subglobose to ellipsoid, finely verrucose, orange yellow, with two germ-pores on one face, $14-21 \times 11-17 \mu$, average $17 \times 14 \mu$; paraphyses intermixed, numerous, hyaline, capitate, over-topping the spores, $50-68 \mu$ long, with head $18-24 \mu$.

- III. Teleutosori minute, dark-brown, flat, irregular, solitary or gregarious.

Teleutospores yellowish-brown, intercellular, subcylindrical or prismatic, $25-37 + 6-9 \mu$.

On leaves and occasionally on stems of *Hypericum japonicum* Thunb.

Victoria—Murramurrangbong Ranges, Nov. and Dec., 1902-3, and Mt. Blackwood, Jan., 1903 (Robinson). Buffalo Mts. and Alps, near Bright, Nov. and Dec., 1903-4 (C. French, jr.). Near Melbourne, Nov., Jan.

The paraphyses are noted as absent by Dr. Plowright in his Monograph of the Uredineae, but in these specimens they are particularly abundant, and form a striking feature of the uredosori. Fischer² also found the paraphyses wanting, and he came to the conclusion with others, that the caeoma form had been mistaken for the uredo, since the spores were in chains. But Klebahn³ has proved the existence of both the caeoma form without paraphyses and the uredo form with paraphyses, so that the three stages may occur on species of *Hypericum*. *Aecidium disseminatum* Berk. is found here on the same host-plant and in the same locality as this species.

LINACEAE.

Linum.128. *Melampsora lini* (Pers.) Tul.

Tulasne, Ann. Sci. Nat., p. 93 (1854).

Cooke, Grev. XI., p. 98 (1883).

Cooke, Handb. Austr. Fung., p. 332 (1892).

Sacc. Syll. VII., p. 588 (1888).

II. Uredosori scattered, rounded, orange, soon pulverulent, up to $1\frac{1}{2}$ mm. diam.

Uredospores round or ovate, bright orange-yellow, echinulate, pedicellate, $15-25 \times 13-18 \mu$, exceptionally reaching a length of 28μ ; paraphyses curved, markedly capitate, $17-20 \mu$ thick.

III. Teleutosori flattened, often confluent, reddish brown, then black, shining.

Teleutospores densely crowded beneath epidermis, cylindrically prismatic, intercellular, polygonal in section, $45-60 \times 17-20 \mu$, very occasionally two-celled.

On leaves and stems of *Linum marginale* A. Cunn. Widely distributed.

Victoria—Near Melbourne, Oct., 1885 (Reader). Ardmora, Kergunyah, Killara, near Melbourne, Rutherglen, &c., Oct., March.

New South Wales—Hume River, 1886 (Jephcott). Guntawang, Mudgee (Hamilton); Merilla, Oct., 1890 (Cobb²).

South Australia—Murray River, 1890 (Tepper), (Ludwig²).

Tasmania—Near Waterworks, Hobart, Jan., 1892 (Rodway¹).

On *Linum usitatissimum* L. wherever flax is cultivated.

Victoria—Near Melbourne, 1902. - Donald, Nov., 1903, II., III.

Port Fairy, Jan., 1904, II., III., &c.

South Australia—Near Adelaide, 1889 (Crawford).

New South Wales—Brungle, 1891 (Cobb⁴).

In the *Journal of Mycology* for 1889, Galloway¹ records this rust as being sent to him from South Australia by the late Frazer S. Crawford, who wrote that it had destroyed a crop of flax near Adelaide, and was likely to spread and prove a troublesome pest. Bolley informs me by letter that in Dakota it is a very abundant rust on all the wild varieties of *Linum*, and is always more or less destructive in the flax crop. He further states that it was especially destructive in 1904, in many cases practically destroying crops which he had bred from seeds supposed to be immune to the wilt disease or flax-sick soil disease.

Dr. Cobb⁴ in the *Agricultural Gazette* of New South Wales for 1891, notes it as causing serious injury to cultivated flax, and in some parts of Victoria, particularly at Port Fairy, I have found it injuring the crop.

(Plate XXVI., Fig. 236; Plate I., Fig. 36.)

CAEOMA Link.

There are several imperfect forms which only occur in one stage and cannot with certainty be assigned to their proper genera. For such it is convenient to have a form-genus, which simply serves as a resting-place until their true affinities are determined. At first they were considered to be independent fungi and had generic names assigned to them. These form-genera are *Caeoma*, *Aecidium*, and *Uredo*, and of the former there are only two known for Australia, one of which was called an *Aecidium* by Cooke and the other a *Uredo* by Berkeley. This is not surprising when one considers that the caeoma is not distinct from the aecidium, as in those cases where the one merges into the other. Thus in *Puccinia prenanthis* (Pers.) Lindr., the aecidial wall is very imperfectly formed, so that the aecidia approach caeoma-forms. Barclay³ also found a variety of this species in Simla, in which there was not a vestige of a peridium, and he considers this, along with others, an interesting example of an intermediate and mostly vanishing stage between *Aecidium* and *Caeoma*. In the aecidial stage of *Puccinia aucta* (*Aecidium lobeliae* Thuem., *A. microstomum* Berk.), the peridial wall was sometimes absent, so that I described it at first as a *Caeoma*.

Caeomata are generally considered to be stages in the life-history of the Melampsoraceae, but since true caeoma-forms occur in connexion with *Puccinia*, and species such as *Melampsora tremulae* Tul. have so-called caeoma-forms as *Caeoma laricis* (Westd.) Hart. with an investment of barren cells, the evidence for this connexion is weakened and the necessity for retaining this as a form-genus much reduced. In Saccardo's *Sylloge Fungorum* the isolated forms are treated as a sub-genus of *Uredo* with subcatenulate spores. They have no special significance here, but elsewhere they form witches'-brooms.

General Characters.—They are simply aecidia without peridia, the spores are produced in chains, with or without paraphyses, and accompanied by spermogonia.

Caeoma-forms, 2.

APOCYNACEAE.

Tabernaemontana.

129. *Caeoma apocyni* McAlp.

I. Sori on both surfaces of leaf, minute, crowded, brownish, bullate.

Spores yellowish, very variable in shape, ellipsoid, ovoid, pear-shaped, oblong or angular, with finely granular contents, 25–34 \times 20–26 μ ; epispore hyaline, coarsely verrucose, 5 μ thick.

On *Tabernaemontana orientalis* R. Br.

Queensland—Brisbane, (Bailey¹).

Mr. Bailey kindly sent me a specimen of this from his herbarium, which had been named by Dr. Cooke *Aecidium apocyni* Schwein., as given in his *Handbook of Australian Fungi*, p. 341 (1902). It has no pseudoperidium, however, and is therefore a *Caeoma*, and since the spores do not apparently agree even with those of *Caeoma* (*Aecidium*) *apocynatum* Schwein., it is constituted a new species.

RANUNCULACEAE.

*Clematis.*130. *Caeoma clematidis* Thuem.

Thuemen, Myc. Univ. No. 539.

Berkeley, Hook. Journ. VI., p. 205 (1854).

Cooke, Handb. Austr. Fung., p. 344 (1892).

Sacc. Syll. VII., p. 867 (1888).

Uredo clematidis Berk.

- I. Sori hypophyllous, generally on pale-green portions of leaf, solitary or arranged in circular groups, more or less rounded, pulvinate, ruddy-brown at first and bright orange when burst.

Spores in rows, bright orange, variable in shape, ellipsoid, ovate, oblong or polygonal, epispore hyaline, scoloped, $22-32 \times 16-20 \mu$.

On living leaves of *Clematis aristata* R. Br., and *C. microphylla* DC.

Victoria—Near Colac, Sept., 1897 (Hill). Phillip Island, Jan.,

1900. Murramurrangbong Ranges, Dec., 1903 (Robinson).

Near Melbourne, Feb. and July, 1904. Frankston, Jan., 1904, Aug., 1904 (Robinson).

Queensland—Bailey¹⁵.

This species was first described from S. Africa as a *Uredo*, but it has the spores in chains and is a true *Caeoma*. Specimens were examined from Thuemen's Myc. Univ. 539 and found to be the same.

AECIDIUM Pers.

Several of the aecidia given in Dr. Cooke's *Handbook of Australian Fungi* are now referred to their proper Puccinias. *A. urticae* is accepted as a stage in the life-history of *Puccinia caricis*, and described in connexion with that form. *A. goodeniacearum*, *A. senecionis* and *A. violae* are placed under their proper *Puccinia* or *Uromyces*, and the aecidium on the daisy (*A. bellidis*) is now found to belong to *P. distincta* McAlp., and to have no connexion, as in Britain, with *P. obscura* on *Luzula*. The most noteworthy aecidium is that found on a grass (*A. danthoniae*), and constitutes the second known example. They often cause deformation of the branches known as witches' brooms, and various swellings, and in some instances compound galls are formed up to 5 cm. across (*A. englerianum*). One species causes thickening and distortion of the leaves in *Veronica*, and nettle stems are often abnormally swollen from the same cause.

General Characters.—Pseudoperidia cup-shaped or urn-shaped, rarely cylindrical, with margin often crenate or lacinate and revolute.

Spores, globose or angular, commonly orange yellow, growing in chains.

Aecidium-forms, 15.

SCROPHULARIACEAE.

*Veronica.*131. *Aecidium disciforme* McAlp.

- O. Spermogonia on under surface of upper and younger leaves, honey-coloured, flat, numerous, minute.

Spermatia hyaline, elliptical, $5-6 \mu$ long.

- I. *Aecidia* on both surfaces of leaves, but mostly on under, bullate, brownish, resembling dotted discs, often confluent, at first entirely enclosed, ultimately opening irregularly by small pore, 1–1½ mm.; peridial cells hyaline, loosely adherent, subglobose, elliptic or lozenge-shaped when united, with striated margin, 25–30 μ .

Aecidiospores orange-yellow, subglobose to elliptic, 16–20 μ diam., or 19–22 \times 14–16 μ .

On *Veronica gracilis* R. Br.

Tasmania—Sandy Bay, Hobart, Aug., 1896 (Rodway).

On *Veronica calycina* R. Br.

New South Wales—Kogarah, Oct., 1900 (Maiden).

This species causes thickening and distortion of the leaves. It is quite distinct from *A. veronicae* Berk., of which there is a portion of the original material in the National Herbarium, Melbourne. The latter forms a regular cup with fimbriate margins, while the former only opens by a minute pore. The spores are also quite different.

Veronica.

132. *Aecidium veronicae* Berk.

Berkeley in Herb., Grev. XI., p. 97 (1883).

Sacc. Syll. VII., p. 814 (1888).

- I. *Aecidia* numerous, crowded, semi-immersed, on under-surface of leaf and a few scattered on upper surface, ½ mm. diam.; pseudoperidia cup-shaped, becoming discoloured and dark-brown with age, with fimbriate margins; peridial cells, oblong to angular, with very broad striated margin, average 32 \times 25 μ .

Aecidiospores dark yellow, variously shaped, ellipsoid, oblong or angular, with finely-granular contents, 24–30 \times 16–20 μ ; epispore hyaline, finely verrucose, about 2 μ broad.

On *Veronica* sp.

Victoria—(F. v. Mueller).

Tasmania—(Rodway).

There is an old specimen in the National Herbarium which had been submitted to Berkeley by the late Baron von Mueller. There are plenty of spores still in the cups, but probably the thoroughly mature ones have fallen away.

(Plate XXXIX., Fig. 287.)

PLANTAGINACEAE.

Plantago.

133. *Aecidium plantaginis-variae* McAlp.

- O. *Spermogonia* on both surfaces of leaf, but mostly on upper, honey-coloured, numerous, 160–180 μ diam.

Spermatia hyaline, elliptical, 4–5 μ long.

- I. *Aecidia* on both surfaces, sub-gregarious or gregarious; pseudoperidia cup-shaped, outstanding, with recurved and lobed margins; peridial cells oblong to lozenge-shaped, or polygonal, with broad striated margin, 35–40 μ long.

Aecidiospores bright orange-yellow, elliptic to oblong, finely echinulate, 22–25 \times 16–23 μ , sometimes reaching a length of 28 μ .

On leaves of *Plantago varia* R. Br.

Victoria—Murrumbidgee Ranges, Nov., 1902 (Robinson).

Mt. Blackwood, March, 1905 (Cyril Brittlebank).

New South Wales—Guntawang, near Mudgee (Hamilton).

Tasmania—Knocklofty, Oct., 1895 (Rodway¹).

This species is given as *A. plantagini* Ces., in Cooke's *Handbook of Australian Fungi*, but there are no spots on the leaves, and the spores are echinulate not tuberculate, as well as considerably larger.

The Victorian specimens were rare, and the fungus was much overrun by *Darlucula filum* Cast.

(Plate XXXIX., Fig. 288.)

GENTIANACEAE.

Limnanthemum.

134. *Aecidium nymphaeoides* DC.

De Candolle, Fl. fr. II., p. 597 (1805).

Cooke, Handb. Austr. Fung., p. 341 (1892).

Sacc. Syll. VII., p. 809 (1888).

- I. Aecidia on upper surface of leaf, gregarious, disposed without order on rounded spots, or in concentric zones; pseudoperidia scutelliform, margin scarcely prominent, entire, or irregularly lacinate.

Aecidiospores orange-yellow, angular, delicately warted, 12–20 μ diam.

On *Limnanthemum indicum* Thw.

Queensland—Near Brisbane, 1884 (Bailey⁴).

This aecidium was first found on the leaves of *Limnanthemum nymphaeoides* Hoff. and Link and its connexion with *Puccinia scirpi* DC., was first suggested by Chodat¹. Then Bubak¹, by means of cultures, proved the connexion, but until the teleuto stage is found in Australia only the aecidium stage will be given.

Specimen not seen.

COMPOSITAE.

Cymbonotus.

135. *Aecidium cymbonoti* Thuem.

Thuemen in Muell. Supp. Phyt. Austr. XI., p. 96 (1880).

Sacc. Syll. VII., p. 833 (1888).

- O. Spermogonia minute, honey-coloured, in groups, surrounded by aecidia, 130–160 μ diam.

Spermatia minute, hyaline, ellipsoid, 3 μ long.

- I. Aecidia on upper surface of leaves, markedly circinate, about $\frac{1}{3}$ mm. diam.: pseudoperidia yellowish, with fimbriate margin; peridial cells considerably overlapping each other, elongated oblong to slipper-shaped, with striated margin and reticulate all over, 28–38 \times 16–17 μ .

Aecidiospores orange-yellow, ellipsoid to sub-globose, finely echinulate, 13–18 \times 13–15 μ .

On *Cymbonotus lawsonianus* Gaudich.

Victoria—Dookie, Jan., 1892 (Pye). Dimboola, May, 1896.
(Reader). Preston, April, 1900 (C. French, jun.). Myrniong
(C. C. Brittlebank).

Some of the specimens were overrun with *Darlucia filum* Cast.

There is no clue to the description of this species, but I have drawn out the above from abundant material.

(Plate XXXIX., Fig. 290.)

Abrotanella.

136. *Aecidium monocystis* Berk.

Berkeley, Flor. N.Z. II., p. 196 (1855).

McAlp., Proc. Roy. Soc. Vic. VII., N.S., p. 218 (1894).

Sacc. Syll. IX., p. 319 (1891).

- I. Aecidia solitary, relatively large ($\frac{3}{4}$ mm. diam.) persistent on the upper surface of the leaves towards their tips, surrounded with a tough border; pseudoperidia white, with margin toothed; peridial cells somewhat wedge-shaped to angular oblong, appearing hexagonal when united, covered with projecting points, $50 \times 22 \mu$.

Aecidiospores pale orange-yellow, ellipsoid, finely verrucose, $25-30 \times 19-22 \mu$.

On leaves of *Abrotanella forsterioides* Hook. f.

Tasmania—Summit of Mt. Wellington, Feb. 1891 (Rodway).

This is a very characteristic species, occurring solitary at the tips of the leaves. It was first recorded on *Phyllachne* (*Helophyllum*) *colensoi* Berggr. from New Zealand, but L. Rodway, Government Botanist of Tasmania, has grave doubts as to the correct determination of the host-plant. He is of opinion that this rust is attributed to New Zealand by mistake, and that it was really found in Tasmania. He informs me that this *Aecidium* is abundant on every tuft of *A. forsterioides*, which grows in profusion near Hobart, and is not likely to have been overlooked by the early botanists. The coloured drawing of the plant in the New Zealand Flora certainly closely resembles *Abrotanella*, and I have forwarded a specimen of the plant to the Director of the Royal Gardens, Kew, for comparison with the original. It is not likely that the same *Aecidium* occurs on a Composite and a Stylidiaceous plant.

(Plate XXXIX., Fig. 291.)

Olearia.

137. *Aecidium oleariae* McAlp.

- I. Aecidia crowded on stems and leaves, generally running in lines lengthwise, about 1 mm.; pseudoperidia round to elongated, with lacerated margins; peridial cells hexagonal, striated, $35-42 \mu$ long.

Aecidiospores orange, elliptic to oblong, with granular contents, $22-26 \times 14-17 \mu$.

On stems and leaves of *Olearia axillaris* F.v.M.

Victoria—Port Fairy, June, 1899 (Robinson).

The aecidia occur most commonly on the stem, and are deeply imbedded in the tissues of this coast shrub.

RUBIACEAE.

Canthium.138. *Accidium plectroniae* Cooke.

Cooke, Grev. X., p. 124 (1882).

Bailey, Queensland Agr. Journ. IV., p. 284 (1899).

Sacc. Syll. VII., p. 795 (1888).

O. Spermogonia on upper surface of same spots which bear the aecidia, sometimes accompanied by one or a few aecidia.

I. Aecidia hypophyllous, rotund, in small clusters on orbicular discoloured spots; pseudoperidia somewhat prominent, whitish, margins sub-entire; peridial cells ovate to somewhat quadrate, punctate all over, and with striate margin.

Aecidiospores yellow, finely echinulate, sub-globose to ellipsoid or polygonal, $25-26 \times 19-20 \mu$, or $22-28 \mu$ diam.

On leaves of *Canthium coprosmoides* F. v. M.

Queensland—Endeavour River (Roth) (Bailey, ^{21, 22}).

The host-plant is sometimes placed under the genus *Plectronia*.

This species was first found on *Canthium* (*Plectronia*) *guenzii* Sond., from Natal, and the spores were undescribed, but I have been able to redescribe it from specimens kindly sent from Queensland by Bailey.

LEGUMINOSAE.

Bossiaea.139. *Accidium eburneum* McAlp.

McAlpine, Proc. Roy. Soc. Vic. VII., N.S., p. 218 (1895).

P. Hennings, Hedw. XL., p. 352 (1901).

Sacc. Syll. XIV., p. 375 (1899).

A. bossiaee P. Hennings, Hedw. XL., p. 352 (1901).

I. Aecidia mostly hypophyllous or on stems and legumes, scattered or in dense clusters, bright orange, average $\frac{1}{2}$ mm. diam.; pseudoperidia cup-shaped, becoming ivory-coloured then brownish, with reflected finely toothed margin; peridial cells polygonal, reticulated, $24-31 \mu$ long.

Aecidiospores ellipsoid, bright orange, very finely echinulate, $18-28 \times 12-17 \mu$.

On *Bossiaea cinerea* R. Br., stems, leaves, flower-stalks, calyx, and legumes.

Victoria—Near Melbourne, Sept.–Nov. (Barnard, Robinson, &c.).

Tasmania—Bellerive swamp (Rodway ¹), and Dec., 1905.

On leaves of *Bossiaea linophylla* R. Br.

West Australia—King George's Sound, July, 1901 (Pritzel).

On fruit of *Bossiaea rhombifolia* Sieber and *B. microphylla* Sm.

New South Wales—Richmond, Nov., 1896, and Falconbridge, Oct., 1904 (Maiden).

On fruit of *Bossiaea heterophylla* Vent.

New South Wales, Sep., 1896 (Maiden).

I have revised the description of *A. eburneum* from fresh specimens, and have no doubt but it is the same as Hennings' species, a specimen of which

he kindly sent me. The spores in both cases are very finely echinulate, and in the West Australian specimens they are $18-23 \times 15-18 \mu$, while in the other they are $18-28 \times 12-17 \mu$.

On the stems of *B. cinerea* there are oval to lenticular swellings, sometimes half an inch long, separate or close together, with dark purplish border, and often becoming depressed in the centre. On the leaf-stalks the swelling may completely surround them, and on the leaf there are brown raised orbicular spots, with aecidia on both surfaces, but sparingly on upper. On the flower-stalks the swellings are similar to those on the leaf-stalks, and on the legumes large circular or irregular patches are formed on margins and both valves.

(Plate XXVII., Fig. 239.)

Platylobium.

140. *Aecidium platylobii* McAlp.

O. Spermogonia honey-coloured, minute, scattered, either associated with or on opposite side to aecidia.

Spermatia very numerous, hyaline, cylindrical, $3 \times 1 \mu$.

I. Aecidia on pallid spots or on swellings on pods, amphigenous, in small groups or in dense clusters, deep orange; pseudoperidia cylindrical, white, with small portion inserted in matrix, margin finely toothed, up to 1 mm. long.

Aecidiospores orange, elliptic to sub-angular, finely warted, $21-25 \times 14-18 \mu$.

On leaves and legumes of *Platylobium formosum* Sm.

Victoria—Murramurrangbong Ranges, Nov., 1902, Dec. 1903, and Jan. 1905 (Robinson).

It is closely related to *Aecidium soleniiforme* Berk., but until further stages are found it will be retained as a distinct species.

While the bright orange aecidia are very conspicuous and very plentiful on both surfaces of the legumes, they are very rare upon leaves, having hitherto only been found on the first or second pair of leaves of young seedlings.

The mycelium bearing the aecidia penetrated the fruit cover and entered the seed, so that the young plant is probably infected from the start.

(Plate XXVII., Figs. 237, 238.)

Goodia.

141. *Aecidium soleniiforme* Berk.

Berkeley, Fl. Tasm. II., p. 270 (1860).

Cooke, Handb. Austr. Fung., p. 340 (1892).

Sacc. Syll. VII., p. 788 (1888).

I. Aecidia on brown orbicular spots, sometimes densely crowded, particularly when on fruit; pseudoperidia cylindrical, elongated up to $\frac{1}{2}$ mm., white, radiately lacinate at margin.

Aecidiospores rather angular, orange, $25-26 \mu$ diam.

On leaves and fruits of *Goodia lotifolia* Salisb.

Victoria—Nov., 1895 (French). Gellibrand River, Dec., 1895 (Hill).

Tasmania—1860 (Archer). (Berkeley¹)

The aecidia, as the specific name denotes, are rather tubular at first.

(Plate XXXIX., Fig. 293.)

AMARANTACEAE.

Deeringia.142. *Aecidium deeringiae* Cooke and Mass.

Cooke and Masee, Ann. Rep. Dept. Agr. Queensland, p. 40 (1893).

O. *Spermogonia* on discoloured spots on the upper surface.

I. *Aecidia* crowded on orbicular pallid spots (2–3 mm.) on the under surface, which are somewhat thickened, semi-immersed, margin white, crenulate.

Aecidiospores sub-globose, very finely echinulate, $12\ \mu$ diam.

On living leaves of *Deeringia celosioides* R. Br.

Queensland—Gladfield (Gwyther), (Bailey.¹²)

The colour of the spores could not be determined in the dried specimens.

Only the name of this fungus was given in the Annual Report, and Dr. Cooke has kindly furnished me with the description in MS.

Uromyces deeringiae Syd. occurs on *Deeringia indica* in Java and the Philippine Islands, but the aecidiospores are $22\text{--}28\ \mu$ diam., so that they are quite distinct from the present form unless there has been a mistake in the transcription of the size of the spores. The host in both cases is the same according to the *Index Kewensis*.

(Plate XXXIX., Fig. 294.)

HYPERICACEAE.

Hypericum.143. *Aecidium disseminatum* Berk.

Berkeley in Hook. Handb. Fl. N.Z., p. 756 (1867).

Sacc. Syll. IX., p. 322 (1891).

I. *Aecidia* on under surface of leaves, causing corresponding elevations on upper surface, sub-gregarious or crowded, sometimes confluent, fully $\frac{1}{3}$ mm. diam.; pseudoperidia raised, with white margin, reflexed, fimbriate; peridial cells sub-quadrangle, average $30 \times 22\ \mu$.

Aecidiospores orange-yellow, sub-ellipsoid to sub-angular, finely verrucose, $16\text{--}17 \times 11\text{--}13\ \mu$.

On *Hypericum japonicum* Thunb.

Victoria—Murramurrangbong Ranges, Nov. 1902, and Dec., 1903 (Robinson).

The original description by Berkeley is very brief: "Spots none or effused. Peridia scattered, short; margin lobed; spores white." Since it was hardly possible from this description to be certain of the species, a specimen was sent to the Royal Gardens, Kew, for comparison with the type specimen there, and it was found to be identical.

This aecidium occurs on the same host-plant as *Melampsora hypericorum* (DC.) Schroet. and is occasionally found on the same leaf with the uredosori.

RANUNCULACEAE.

Caltha.

144. *Aecidium calthae* Grev.

Greville, Fl. Ed., p. 446 (1824).

McAlpine, Proc. Linn. Soc. N.S.W., XXIV., p. 301 (1899).

Sacc. Syll. VII., p. 602 (1888).

O. *Spermogonia* arranged in small groups, honey-coloured.

I. *Aecidia* distributed on upper surface of leaf and often confluent, about $\frac{1}{2}$ mm. diam.; pseudoperidia white, margin lacinate; peridial cells pentagonal or hexagonal, margin finely streaked, 28–32 μ .

Aecidiospores bright orange, angular to sub-globose or oval, finely echinulate, average 22–23 \times 17–20 μ .

On living leaves of *Caltha introloba* F. v. M.

New South Wales—Mt. Kosciusko, Jan., 1899 (Maiden).

I have provisionally named this as above, although Greville describes the aecidium as hypophyllous and on the petioles, while here it was epiphyllous, and only on the blade of the leaf. However, the spores and pseudoperidial cells quite agree with British specimens. The host-plant is indigenous to Australia, and was found in a rocky creek, on eastern side of Mueller's Peak, Mt. Kosciusko, at a height of about 6,500 feet. This was the only micro-fungus found there by Mr. Maiden. The Puccinia-stage of this fungus occurs in Europe and America, and has hitherto only been found on the marsh marigold (*Caltha palustris* L.); until that stage has been discovered here, it cannot be definitely stated that the two fungi are the same.

(Plate XXXIX., Fig. 295.)

Ranunculus

145. *Aecidium ranunculacearum* DC.

De Candolle, Fl. fr. VI., p. 97 (1805).

Cooke, Handb. Austr. Fung., p. 340 (1892).

Sacc. Syll. VII., p. 776 (1886).

I. *Aecidia* hypophyllous or surrounding lobes of leaf and on stalk, densely crowded, very bright orange, often causing a swelling; pseudo-peridia cup-shaped to cylindrical, whitish, with margin brittle and lacerated, 1 mm. high; peridial cells somewhat quadrate and tapering to a point where they dovetail into each other, with striated margin, 27–28 \times 18–22 μ .

Aecidiospores orange-yellow, polygonal to oblong or ellipsoid, very finely echinulate, 17–30 \times 14–20 μ , average 22 \times 17 μ .

On *Ranunculus parviflorus* L., *R. rivularis* Banks and Sol., *R. lappaceus* Sm. and *R. gunnianus* Hook.

Victoria—Mount Emu Creek, 1854. Omeo, Nov., 1882 (Stirling).

Ardmona, 1896 (Robinson). Near Dimboola, Nov., 1897

(Reader). Murrumbidgee Ranges, Nov., 1902 (Robinson).

Buffalo Ranges, Dec., 1904 (C. French, jun.).

On *Ranunculus* sp.

New South Wales—Guntawang and Mudgee (Hamilton). Richmond (Musson).

Tasmania—St. Patrick's River, Nov., 1844 (Gunn), (Berkeley').

This aecidium occurs on several species of *Ranunculus*, and varies somewhat in general characters, although the aecidiospores all agree in being very finely echinulate. As the result of cultures, this has been found to be

a composite species, the aecidiospores infecting various grasses on which they produce uredo and teleutospores. Until similar experiments are carried out here, the different aecidia, occurring on species of *Ranunculus* must be grouped together.

Darlucula filum Cast. was found associated with the aecidia.

(Plate XXXIX., Fig. 296.)

UREDO Pers.

This stage probably belongs to teleutospore-forms which have not been observed, and which may only rarely be produced. But it is also quite possible that some may possess a perennial mycelium, and dispense with the necessity of forming teleutospores. Several in Dr. Cooke's *Handbook of Australian Fungi* have been referred to their proper genera. *U. notabilis* Ludw., belongs to *Uromycladium notabile*, and *U. armillata* Ludw., to *Puccinia juncophila*. *U. clematidis* Berk., has already been shown to be a *Caeoma*, and *U. cichoracearum* DC., as determined by Cooke, belongs to *U. bidentis* P. Henn.

General characters.—Sori without pseudoperidium, covered or erumpent, for the most part orange-yellow, rather pulverulent, and spores produced singly on the terminal ends of hyphae, never smooth. Germination by germ-tube, which enters the host-plant through stomata.

Uredo-forms, 13.

GRAMINEAE.

Saccharum.

146. *Uredo kuehnii* Krueg.

Krueger, Bericht. Zuck. Java IX., p. 117 (1891).

Cobb, Agr. Gaz. N.S.W. IV., p. 799 (1893).

Sacc. Syll. XI., p. 182 (1895).

Uromyces kuehnii Krueg.

II. Sori mostly hypophyllous, linear, at length bursting through epidermis and forming elongated brownish or blackish narrow streaks, single or confluent, with clavate, brown paraphyses.

Uredospores globose to ellipsoid or piriform, brown or orange, rather thin-walled, echinulate, $47-53 \times 28-35 \mu$; pedicels hyaline, clavate, somewhat shorter than spore.

Common on leaves of *Saccharum officinarum* L.

New South Wales—Clarence River (Cobb⁷).

Queensland—Brisbane and Mackay, 1898 (Tryon⁵).

Dr. Cobb found the spores to possess four equatorial germ-pores, and I have given his measurements, although Krueger makes them out to be $28-57 \times 18-34 \mu$.

Specimen not seen.

CYPERACEAE.

Scirpus.

147. *Uredo scirpi-nodosi* McAlp.

II. Sori bullate, elongated, splitting lengthwise, running in lines on stem, $1\frac{1}{2}-2$ mm. long.

Uredospores brown, subglobose, ellipsoid to oblong, variable in size, $25-32 \mu$ diam., or $27-36 \times 19-25 \mu$; epispore echinulate, often 3μ thick.

On *Scirpus nodosus* Rottb.

Victoria—Mordialloc, Dec., 1885 (Reader) (Winter ?).

This specimen is given as *Puccinia rimosa* (Link) Wint., by Winter, but on carefully examining some of the original material, there are coarsely echinulate uredospores and nothing else. It is evidently not that species described by Winter in Hedwigia, p. 28 (1880), and since it does not agree with the uredo stage of *Puccinia scirpi* DC. of which I have examined specimens from Sydow's Ured. Exs. 685 on *Scirpus lacustris* L., I have named it as above.

(Plate XXVIII., Fig. 241.)

LILIACEAE.

Wurmbea.

148. *Uredo anguillariae* Cooke.

Cooke, Grev. XIV., p. 11. (1885).

Cooke, Handb. Austr. Fung., p. 343 (1892).

Sacc. Syll. VII., p. 840 (1888).

II. Sori on both surfaces, gregarious, elliptic, bullate, long covered by the epidermis.

Uredospores globose or globosely oval, smooth, brown, epispore thin, $20-22 \times 20 \mu$, on short deciduous hyaline pedicels.

On leaves of *Wurmbea (Anguillaria) dioica* F. v. M.

New South Wales—Guntawang (Hamilton).

It is curious to note that Cooke and Massee have also described a *Puccinia* with uredo and teleutospores on this plant, the uredospores being $25-28 \times 15-18 \mu$.

Specimen not seen.

Geitonoplesium.

149. *Uredo geitonoplesii* McAlp.

II. Sori on under surface of leaves on vinous patches, in small groups minute, elliptical, ultimately rupturing epidermis.

Uredospores yellowish to yellowish brown, elliptical to ovoid, very finely echinulate, $19-27 \times 17-19 \mu$.

On *Geitonoplesium cymosum* A. Cunn.

Victoria—Orbost, July, 1901 (Pescott).

Schelhammera.

150. *Uredo schelhammerae* McAlp.

II. Uredosori epiphyllous, yellowish-brown, round to ellipsoid, compact, scattered or in groups, occasionally confluent, soon naked and surrounded by ruptured epidermis, $\frac{1}{2}$ mm. diam. or up to 1 mm. long.

Uredospores golden yellow, ellipsoid to obovate, very finely echinulate, usually with two germ-pores on one face, $22-26 \times 15-20 \mu$, average $24 \times 18 \mu$.

On *Schelhammera undulata* R. Br.

New South Wales—Kurrajong Heights, 1892 and 1903 (Musson).

RHAMNACEAE.

*Spyridium, Pomaderris.*151. *Uredo spyridii* Cooke and Mass.

Cooke and Masee, Grev. XV., p. 99 (1887).

Cooke, Handb. Austr. Fung., p. 343 (1892)

Sacc. Syll. VII., p. 861 (1888).

- II. Sori hypophyllous, punctiform, generally scattered, sometimes confluent, ochraceous to snuffy brown, soon bursting through epidermis, pulverulent.

Uredospores yellowish to orange-yellow, ellipsoid to obovate, distinctly echinulate, with coarsely granular contents, $22-31 \times 17-22 \mu$; paraphyses enveloping sori, long, curved, tufted, hyaline to pallid, generally slightly swollen at apex.

On leaves of *Spyridium parvifolium* F.v.M.

Victoria—Oakleigh, June, 1886 (Watts). Sept., 1887 (Mrs. Martin). Murramurrangbong Ranges, Dec., 1903, and Jan., 1905 (Robinson).

On *Pomaderris apetal*a Labill.

Victoria—Murramurrangbong Ranges, Jan., 1905 (Robinson).

Tasmania—Devonport, Jan., 1906 (Robinson).

On both genera of host plants the sori are surrounded by paraphyses.

The rust is very plentiful on the leaves, and, although a large quantity of material has been examined at different seasons of the year, only the uredo-stage has been found.

(Plate XXVIII., Fig. 245.)

STYLIDIACEAE.

*Stylidium.*152. *Puccinia stylidii* McAlp.

- II. Sori on both surfaces of leaf, solitary or sub-gregarious, elliptic, bullate, and splitting raised epidermis, sometimes confluent laterally, reaching 1 mm. or more in length.

Uredospores orange-yellow, elliptic to subglobose, echinulate, with solitary germ-pore on one face, $22-24 \times 16-18 \mu$, or $22-24 \mu$ diam.

- III. Teleutosori, p. 210.

On leaves of *Stylidium graminifolium* Sm.

Tasmania—New Waterworks, Hobart, Nov. 1892, II. (Rodway).

Darluca filum, Cast., literally covered some of the sori.

(Plate XXVIII., Fig. 242.)

COMPOSITAE.

*Bidens.*153. *Uredo bidentis* P. Henn.

Hennings, Hedw. XXXV., p. 251 (1896).

Sacc. Syll. XIV., p. 395 (1899).

- II. Sori scattered or densely gregarious, amphigenous, most numerous on under surface, minute, pulvinate, then flattened or somewhat patelliform, ochraceous, surrounded by the epidermis.

Uredospores ovoid, ellipsoid or subglobose, yellow or pale brown, episore pale chestnut-brown, $2-3 \mu$ thick, finely echinulate or almost smooth, $25-35 \times 22-27 \mu$, in exceptional cases 41μ long; paraphyses numerous, hyaline, clavate, $50-60 \mu$ long.

On leaflets and leaf stalks of *Bidens pilosa* L.

Queensland—Brisbane, 1886 (Bailey⁵).

Part of the original specimen named by Dr. Cooke *Uredo cichoracearum* DC., was kindly forwarded to me by Mr. Bailey, and on comparing it with the above species in Exsicc. Syd. Ured., 1647, it was found to be the same. Even the paraphyses, which are not recorded by Hennings, occurred in both.

Puccinia bidentis Diet. and Holw. was described in the *Botanical Gazette*, XXIV., 32 (1897), on a species of *Bidens* in Mexico, and probably is the complete stage of this uredo. The original species was founded on *Bidens pilosa* from Brazil.

(Plate XXVIII., Figs. 243–244.)

Crepis.

154. **Uredo crepidis-japonicae** Lindr.

Lindroth, Acta Soc. Fauna et Flora fennica, XXII., p. 11 (1902).

Sacc. Syll. XVII., p. 438 (1905).

II. Sori amphigenous, but often hypophyllous, cinnamon brown, round, minute, at first surrounded by epidermis.

Uredospores sub-globose or broadly ellipsoid, yellowish, finely echinulate, with three scattered germ-pores and epispore $1\ \mu$ thick, 14–18 μ diam.

On leaves of *Crepis japonica* Benth.

Queensland.

Specimen not seen.

Olearia.

155. **Puccinia oleariae** McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 756 (1895).

Sacc. Syll. XIV., p. 278 (1899).

Uromyces asteris McAlp.

II. Uredosori hypophyllous, pulvinate, scattered, bright orange.

Uredospores oval or irregularly pear-shaped to spatulate, stalked, bright orange, apiculate at apex and somewhat thickened, with three equatorial pores on one face, $39\text{--}51 \times 19\text{--}24\ \mu$; epispore longitudinally striate, average thickness $1\frac{1}{2}\ \mu$; pedicels relatively short, hyaline, and continuous with spore.

III. Teleutosori similar but brownish.

Teleutospores intermixed with uredospores, bright orange, oblong to oblong-clavate, smooth, fragile, constricted at septum, rounded at apex, generally tapering slightly towards base, $62\text{--}90 \times 18\text{--}28\ \mu$; pedicel hyaline, persistent, short, up to $56\ \mu$ long.

X. Mesospores occasional, similarly coloured, elongated ellipsoid, rounded at both ends, $60\text{--}68 \times 18\text{--}22\ \mu$.

On leaves of *Olearia argophylla* F. v. M. (*Aster argophyllus* Labill.).

Tasmania—Near Hobart, November, II. (Rodway¹). Cataract Gorge, Jan., 1906, II., III. (Robinson).

This species was originally described as *Uromyces asteris*, but on extended critical examination of the type material I placed it in the genus *Uredo* on account of the number of the equatorial germ-pores. Since then additional material has been found, showing it to be a *Puccinia*.

(Plate XXVIII., Fig. 249.)

PROTEACEAE.

*Hakea.*156. **Uredo angiosperma** Thumen.

Thumen, Symb. Myc. Austr. IV., No. 95 (1880).

Cooke, Handb. Austr. Fung., p. 343 (1892).

Sacc. Syll. VII., p. 840 (1888).

- II. Sori on both surfaces, large, commonly disposed about a circle, covered by the splitting, torn, and elevated epidermis, powdery, brown.

Uredospores oval or ellipsoid, rounded at the apex, somewhat narrowed at the base, $45 \times 30 \mu$; epispore smooth, pale brownish, $5-7 \mu$ thick.

On living leaves of *Hakea* sp.

West Australia—Oct., 1877 (F. v. Mueller) (Thumen²).

Specimen not seen.

CRASSULACEAE.

*Tillaea.*157. **Uredo tillaeae** McAlp.

McAlpine, Agr. Gaz. N.S.W. VI., p. 757 (1895).

Sacc. Syll. XIV., p. 390 (1899).

- II. Sori hypophyllous, minute, round to oval, sometimes confluent.

Uredospores variable in size and shape, usually globose or somewhat oval, smooth, orange-yellow, about 19μ diam. or $20 \times 16 \mu$.

On leaves of *Tillaea sieberiana* Schult.

Victoria—Studley Park, near Melbourne (Barnard).

LEGUMINOSAE.

*Bossiaea.*158. **Uredo bossiaeae** McAlp.

- II. Uredosori on both surfaces of leaves but mostly on under, chocolate brown, erumpent, surrounded by ruptured epidermis, compact, scattered or aggregated, sub-globose, $1-1\frac{1}{2}$ mm. diam.

Uredospores elliptic, finely echinulate, golden-brown, epispore about 3μ thick, $24-31 \times 17-21 \mu$.

On leaves of *Bossiaea prostrata* R. Br.

Tasmania—Hobart, April, 1893 (Rodway).

An *Aecidium* has been found on species of *Bossiaea* in West Australia, Victoria, New South Wales, and Tasmania, but there is no evidence to connect it with this form. It is also noteworthy that a *Cronartium* is found on species of *Bossiaea*.

(Plate XXVIII., Fig. 246.)

*Cassia.*159. **Uredo pallidula** Cke. and Mass.

Cooke and Masee, Grev. XXII, p. 37 (1893).

Sacc. Syll. XI., p. 222 (1895).

- II. Sori pallid, convex, gregarious, splitting irregularly and then girt by the ruptured epidermis, on both surfaces.

Uredospores pulverulent, tawny in the mass, pale-yellow by transmitted light, elliptical to ovoid, finely echinulate, $16-19 \times 12-13 \mu$.

On leaves, twigs, and legumes of *Cassia* sp.

Queensland—Gladfield (Gwyther) (Bailey¹³).

In the original description, the spores are given as smooth, and 12–14 \times 8–10 μ , but on examining material kindly supplied by Mr. Bailey, of Brisbane, they were found to be as above.

(Plate XXVIII., Fig. 247.)

CHENOPODIACEAE.

Rhagodia.

160. *Uredo rhagodiae* Cke and Mass.

Cooke and Massee, Grev. XV., p. 99 (1887).

Cooke, Handb. Austr. Fung., p. 343 (1892).

Sacc. Syll. VII., p. 859 (1888).

II. Sori hypophyllous, scattered, globose, ruddy-brown, a long time covered, at length torn and girt by the remains of the epidermis, up to 1 mm. diam.

Uredospores yellowish, ellipsoid, echinulate, with four or more scattered germ-pores on one face, 24–30 \times 17–22 μ .

On leaves of *Rhagodia billardieri* R. Br.

Victoria—Botanic Gardens, Melbourne, June, 1886 (Watts).

Sandringham, April, 1905 (Robinson).

Cooke and Massee gave measurements of spores as 20 \times 15 μ from Watts' specimen from Botanical Gardens, Melbourne. I have been able to examine part of that same material returned by Cooke and Massee to the National Herbarium and find the spores to measure 24–30 \times 17–22 μ . The rust is fairly abundant along the eastern shores of Port Phillip, and in fresh material examined the spores have the same measurements, roughly about 27 \times 20 μ .

Darlucia filum Cast. is often found on the sori.

(Plate XXX., Fig. 267.)

EXCLUDED OR DOUBTFUL SPECIES.

When one considers that specimens of the various Rusts have hitherto been mostly sent to Britain or Germany for determination, it can readily be understood that sometimes the material was in an imperfect condition or not in the best possible state for proper examination. Hence in some cases the species were wrongly determined, and there are several recorded in Cooke's *Handbook of Australian Fungi*, which on further investigation must be removed from the list of Australian species. Sometimes, although rarely, it happened that the host-plant of the parasite was wrongly given, and then a new species has been created which afterwards turned out to be a known one. On these and other grounds the following are excluded:—

1. *Uromyces amygdali* Pass.—Cooke determined this on Peach and Almond leaves from Victoria, New South Wales, and Queensland, but when complete specimens were examined it was found to be merely the uredo-stage of *Puccinia pruni* Pers.

2. *Uromyces junci* (Desm.) Wint.—This species has not been found in Australia, as it was wrongly determined at Kew Herbarium for *Puccinia juncophila* Cooke and Mass.

3. *Puccinia acetosae* (Schum.) Koern.—This rust was determined by Cooke on a native species of *Rumex*, but on the examination of a specimen in the National Herbarium, Melbourne, named in his own handwriting, it

was found to agree with *P. ludwigii* Tepper. *P. acetosae* and its synonym, *P. rumicis* Lasch. are therefore excluded.

4. ***Puccinia aegra*** Grove.—*P. depauperans* (Vize) Syd.—The rust on the native violets (*Viola hederacea* and *V. betonicifolia*) is comparatively common, and has been collected at various localities in Victoria, New South Wales, and Tasmania. It was at first determined by Winter as this species, and Cooke has also recorded it, but the examination of numerous specimens, including part of the same material forwarded to Dr. Cooke, showed the teleutospores to be warted, not smooth, and aecidiospores likewise finely warted, and therefore not this species.

5. ***Puccinia apii*** Desm.—The rust found on Celery, both native and imported, in Australia, is found to be quite distinct from this species.

6. ***Puccinia caulicola*** Corda is given by Cooke on *Hypochoeris glabra*, but the species on this host-plant is undoubtedly *P. hypochoeridis* Oud.

7. ***Puccinia geranii*** Corda was the name given by Cooke to the rust occurring on *Pelargonium australe*, but it is now found to be a different species, *P. morrisoni* McAlp.

8. ***Puccinia investita*** Schw. was determined by Dr. Morrison on species of *Gnaphalium*, but on investigating the original material I found it to be *P. gnaphalii* (Speg.) P. Henn.

9. ***Puccinia microseris*** McAlp.—Since the host-plant of this species was really *Hypochoeris radicata* it is now excluded.

10. ***Puccinia phragmitis*** (Schum.) Koern.—This species has not yet been found in Australia, only *P. magnusiana* Koern and *P. tepperi* Ludw.

11. ***Puccinia rimosa*** (Link.) Wint.—This species is given by Winter² as occurring on *Isolepis nodosa* R. Br. = *Scirpus nodosus* Rottb. in Victoria, but an examination of the original material only shows uredospores which do not agree with those of this species, and Sydow¹ has arrived at the same conclusion. The local specimen I have named *Uredo scirpi-nodosi*.

12. ***Puccinia violae*** (Schum.) DC.—This species is also given by Cooke as occurring on violets in Victoria, but the history of the specimens shows how necessary it is to guard against recording species as Australian which may have been imported in the dry condition. The original material, with the name in Cooke's handwriting, is accompanied by the following note from the collector, Mr. Reader:—"On leaves of what appears to be *Viola* sp. found in an old book." I was so convinced, however, that *P. violae* did not occur on our native violets, and had not been found growing on cultivated species, that I communicated with the collector, who informed me that the leaves on which this species was found had been brought from Europe and forwarded with other specimens for determination to Dr. Cooke. Unfortunately, on the strength of this determination, Mr. Tryon, in Queensland, and others, have also credited Australia with this species. Mr. Reader, who is a chemist, also sent myself some jaborandi leaves (*Pilocarpus pennatifolius*, Lem.) with a rust upon them, and it was found to be *Puccinia pilocarpi* Cooke, but of course it had been imported.

13. ***Cronartium asclepiadeum*** (Willd.) Fries.—This widely distributed species is recorded on a leguminous plant from Queensland, and the name is given in Berkeley's handwriting on the specimen in the National Herbarium. Dietel, however, regards it as a new species, and has named it *C. jacksoniae*.

14. ***Melampsora nesodaphnes*** B. and Br.—This species was found on the fruit of *Beilschmiedia* (*Nesodaphne*) *obtusifolia* Benth., sent by Bailey to Berkeley from Queensland, and I also found it on the fruit of *Cinnamomum oliveri* Bail., sent by Baker from New South Wales. There is a mass of powdery spores on the surface of the fruit which is swollen and distorted.

These spores are exceedingly numerous, and very variable in size and shape. They are hyaline individually, although ochraceous in the mass and finely granular. They vary from elliptic to ovoid or pear-shaped, and are occasionally slightly curved. There is a clear central axis to the spore, and it is generally broken in the centre, or may be several times transversely divided. Their average size is $24-32 \times 9-10 \mu$. They are usually borne on short hyaline filaments, and occasionally a long filament is adherent to a detached spore.

There is nothing in the appearance or nature of this fungus to indicate that it is a Uredine; it rather suggests some form of Hyphomycete.

15. **Aecidium apocyni** Schwein.—The specimen referred by Cooke to this species is *Caecoma apocyni*.

16. **Aecidium barbareae** DC.—The Cruciferous host-plant is not a *Barbarea*, and a portion of the original specimen shows teleutosori as well as aecidia. I have named the rust *Puccinia cruciferae*.

17. **Aecidium bellidis** Thuem., was determined by Cooke on *Bellis perennis* from Victoria. This is considered to represent the aecidial stage of *Puccinia obscura* Schroet. which occurs on *Luzula*, but since teleutospores have been found from year to year on Victorian specimens along with the aecidia, it is evidently quite a distinct species. I have, therefore, named it *Puccinia distincta*.

Mr. Cheeseman, one of our leading nurserymen, informs me that the seeds of *Bellis perennis* are imported from England and Germany, mostly from the latter country. He also states that some have had to give up growing the plants on account of the rust (*Puccinia distincta*), since it attacks the youngest seedlings sometimes, and at other times the plants remain healthy till late in spring and then become badly attacked. One would naturally conclude that the rust had been imported with the seed, but it is strange that no teleutospores have been found accompanying the aecidia in the countries named. Although I have provisionally recorded it as a native rust, the probabilities are that it will be found to exist in the countries from which the seed has been derived.

18. **Aecidium compositarum** Mart.—All the species occurring on Compositae have been distributed among their respective host-plants.

19. **Aecidium plantaginis** Ces.—The species on the native *Plantago varia* is distinct from this, the spores being echinulate instead of tuberculate, and considerably larger. It has been named *A. plantaginis variae*.

20. **Aecidium senecionis** Desm.—This has also been determined in the absence of complete specimens, but since the teleutospores have been found associated with the aecidia, it has been determined as a new species by Dietel, and named *P. tasmanica*. It is a striking fact that on three such common imported plants as the garden daisy, *Bellis perennis*, groundsel, *Senecio vulgaris*, and marigold, *Calendula officinalis*, there should have been new species of *Puccinia* discovered. As regards the groundsel, aecidia have been found on native species of *Senecio*, probably belonging to the same rust.

21. **Aecidium violae** Schum., is also recorded, but this belongs to *P. violae*, and is therefore excluded.

22. **Uredo cichoracearum** DC. originally determined by Dr. Cooke on *Bidens pilosa* is now found to be *U. bidentis* P. Henn.

23. **Uredo leguminum** Desm.—This species originally occurred on *Phaseolus*, and is recorded by Cooke as being found on pods of *Acacia* in Queensland, but since there is every reason to believe that the rust on a bean is distinct from that on a wattle it is excluded from the list. Probably it is a stage of a *Uromycladium*.

ADDENDA.

AMARANTACEAE.

Polycnemum.161. *Uromyces polycnemi* McAlp.

- I. Aecidia bright orange, generally covering lower surface of leaves, crowded, cylindrical, surrounded at base by ruptured epidermis, up to $1\frac{1}{2}$ mm. long; pseudoperidia colourless, with toothed margin; peridial cells oblong to somewhat lozenge-shaped, with moderately thick striated margins, $37-40\ \mu$ long.

Aecidiospores orange, ellipsoid to oblong or sub-globose, very finely echinulate, $22-23 \times 17-20\ \mu$ or $20-22\ \mu$ diam.

- II. Uredo-sori on both surfaces of leaf, bullate, at first covered by leaden-coloured epidermis, then splitting, scattered or gregarious, sometimes confluent, up to 2 mm. in diam.

Uredospores ellipsoid to oval, orange coloured, finely echinulate, with three equatorial germ-pores on one face, $28-32 \times 18-22\ \mu$.

- III. Teleuto-sori similar to uredo-sori, but generally larger and darker in colour.

Teleutospores dark golden-brown in mass, tawny brown individually, ellipsoid to elongated ellipsoid, rounded at both ends, occasionally slightly thickened at apex and germ-pore prominent, smooth, $34-46 \times 17-25\ \mu$; pedicel hyaline, persistent, comparatively short.

On *Polycnemum pentandrum* F.v.M.

Victoria—Port Fairy. Dec., 1905.

The aecidia were very conspicuous, often covering the under surface of every leaf, and as the host plants grew in dense masses, in the saline marshes near the coast, it was difficult to find one without the rust.

A *Tuberculina* was frequently parasitic on the aecidia.

(Plate XLIII., Fig. 319.)

STYLIDIACEAE.

Stylidium.152. *Puccinia stylidii* McAlp.

- II. Uredosori, p. 204.

- III. Teleutosori on both surfaces of leaf, dark-brown to black, round to elliptic, sometimes confluent in long lines, pulvinate, splitting and surrounded by epidermis, up to $1\frac{1}{2}$ mm. or longer.

Teleutospores at first intermixed with uredospores, bright chestnut-brown, clavate to oblong, smooth, slightly constricted at septum, rounded or bluntly pointed and thickened at apex ($9-11\ \mu$), rounded or attenuated at base, not infrequently three-celled, very variable in shape and size, $40-62 \times 17-28\ \mu$; pedicel hyaline, persistent, up to $45\ \mu$ long.

- X. Mesospores common, similarly coloured to teleutospores, thickened at apex, oval to ovoid or elongated ellipsoid, $30-40 \times 15-23\ \mu$.

On leaves of *Stylidium graminifolium* Sm.

Tasmania—Devonport, Jan., 1906 (Robinson).

Only the uredospores were at first sent by Rodway in Nov., 1892, and the discovery of the final stage shows that *Uredo stylidii* is a *Puccinia*, the description of which is now completed.

G L O S S A R Y.

- Abstriction*.—The formation of a spore by pinching off the end of a spore-forming hypha, without the production of a septum.
- Aecidiospore*.—A spore formed in an aecidium, serially and successively abstricted.
- Aecidium*.—A spore-body consisting of a cup-shaped envelope or peridium with a hymenium at the bottom of the cup, from which aecidiospores are successively detached; also the generic name originally applied to the aecidiospores.
- Amphigenous*.—Growing on both surfaces of a leaf.
- Amphispore*.—A modified uredospore with thickened wall, and only germinating after a resting period.
- Appressorium*.—The vesicle formed by the tip of a germ-tube over the stoma of a leaf before entering it.
- Autoecious*.—Applied to a parasitic fungus of which all the spore-forms are capable of being produced on the same host.
- Basidium*.—The mother-cell or hypha from which spores are given off.
- Basipetal*.—Growing in the direction of the base from above downwards.
- Bullate*.—Raised like a blister.
- Caeoma*.—A spore-layer in which the spores are formed in chains but without an envelope of peridial cells; an aecidium without a peridium.
- Caeomospore*.—A spore formed in a caeoma.
- Capitate*.—Ending in a head, as when the free end of an upright hypha enlarges in a spherical manner.
- Chemotaxis*.—A form of sensitiveness which certain organisms possess towards certain chemical substances.
- Circinate*.—Arranged in a circular manner or nearly so.
- Clavate*.—Club-shaped, enlarging towards the apex.
- Deciduous*.—Falling away, applied to the pedicel of a spore when it does not remain attached to it.
- Echinulate*.—Covered with short spines.
- Elliptical*.—Shaped like an ellipse or oval.
- Endochrome*.—The peculiar colouring matter in the cells, and usually applied to the coloured cell-contents of spores.
- Endospore*.—The innermost coat of a spore.
- Epiphyllous*.—Growing on the upper surface of a leaf.
- Epiteospore*.—A name suggested for a uredospore which functions as an aecidiospore, and the sorus contains or is surrounded by prominent paraphyses.
- Eruptent*.—Bursting through the surface of the host-plant.
- Fimbriate*.—Fringed, when the margin is bordered by slender processes.
- Form-genus*.—A genus in which the species are only represented by single stages of what is believed to be an incomplete life-history, as *Uredo*, *Aecidium*.
- Gall*.—A morbid enlargement or hypertrophy of the cells of a plant, due to parasitic agency.
- Gametophyte*.—The stage in the life-cycle of the plant which bears the sexual organs.
- Germ-pore*.—An opening on the surface of a spore through which the germ-tube passes.
- Germ-tube*.—A tubular process developed from the spore in germination, and may either become a mycelium or promycelium.
- Gibbous*.—Swollen at the base.
- Globose*.—Spherical.
- Haustorium*.—A short lateral branch of a hypha, penetrating a cell of the host-plant and acting as a sucker as well as an organ of attachment.
- Heteroecious*.—Applied to a parasitic fungus of which certain spore-forms occur on one host and others on plants widely remote.
- Host*.—A plant which nourishes a parasite.
- Hyaline*.—Colourless or translucent.

Hymenium.—A spore-bearing layer of hyphae.

Hypertrophy.—An abnormal enlargement or excessive growth of particular parts, which may be caused by excess of nourishment or induced by parasites.

Hypha.—A tubular thread-like cellular structure, collectively constituting the vegetative body or mycelium of the fungus.

Hypophyllous.—Growing on the under surface of a leaf.

Indigenous.—Native to a country, and not introduced.

Intercellular.—Between the cells of the host-plant.

Intracellular.—Within the cells of the host-plant.

Laciniate.—Cut up into narrow lobes.

Lumen.—The cavity bounded by the walls of an organ.

Mesospore.—A single-celled spore-form related to the teleutospore, and probably representing a transition from the unicellular Uromyces.

Micron or *Micromillimetre*.—Indicated by the sign μ , is the standard unit for microscopical measurements, and equals 1-1000th of a millimetre, or 1-25,000th of an inch.

Mutation.—That kind of variation produced by internal influences, in which the equilibrium of the organism is disturbed and a new position of equilibrium found strikingly different from the original one, sometimes called spontaneous variation.

Mycelium.—The vegetative portion of a fungus composed of one or more hyphae.

Nucleus.—An organized proteid constituent of the cell, necessary for its continued growth and life.

Obligate parasite.—One in which a parasitic mode of life is indispensable for complete development.

Orbicular.—Applied to a flat body with a circular outline.

Papillate.—Covered with protuberances or terminating in a papilla.

Paraphyses.—Barren filaments associated with the spores, either slender or variously swollen, hyaline or coloured.

Parasite.—An organism living on or in another living organism, and at its expense.

Pedicel.—Spore-bearing stalk.

Persistent.—Lasting, not soon falling away, applied to the pedicel of a spore.

Piriform.—Pear-shaped.

Plasmodium.—A mass of naked protoplasm, containing many nuclei and exhibiting movement.

Plurivorous.—Applied to a parasite which can exist on a variety of host-plants.

Predisposition.—The tendency to disease exhibited by an organism when the conditions are favorable to the development of the parasite.

Primordia.—The beginnings of any structure, such as the aecidium.

Promycelial spore.—The spore produced by a promycelium, also known as a sporidium.

Promycelium.—The short germ-tube of a teleutospore, which produces a few spores unlike the teleutospores, and then perishes.

Protomycelium.—A term used by Eriksson to denote the early plasmodia-like stage of the mycelium in certain Rusts.

Protoplasm.—The living substance in plants, consisting of albuminoid matter.

Pseudo-parenchyma.—False tissue or compact mycelium, so called because it is formed by the union of previously separate elements or hyphae into a dense mass, while true tissue is derived from a single cell, which divides and forms a coherent, more or less firm, mass of cells.

Pseudo-peridium.—The outer envelope of the aecidium, consisting of sterile cells.

Pulverulent.—Powdery

Pulvinate.—Cushion-shaped.

Reticulate.—Covered with lines or ridges crossing each other so as to form a network.

Saccate.—Bag-shaped.

Saprophyte.—A fungus which preys upon dead organic matter only, in contrast to a parasite.

Septate.—Partitioned off into distinct divisions.

Sorus.—A cluster of spores constituting a spore-bed, as uredosorus, teleutosorus.

- Spermatium*.—A minute detachable cell produced in a spermogonium, and formerly considered to have a male sexual function.
- Spermogonium*.—The receptacle in which spermatia are produced and detached. It is sometimes called a pycnidium, although that term is generally reserved for a spore-receptacle in another division of Fungi.
- Spore*.—A detachable cell, capable of reproducing the fungus.
- Sporidiolum*.—Spore produced by the germ-tube of a teleutospore. Also called sporidium, but since this term is already used as equivalent to an ascospore, Saccardo has proposed the present name.
- Sporophyte*.—The stage in the life-cycle of a plant which bears the spores.
- Sterigma*.—A delicate stalk from which a spore is detached and arising from a basidium.
- Stoma*.—A breathing pore or aperture in the epidermis forming a means of communication between the inside of the plant and the outer air.
- Stroma*.—A cushion or receptacle bearing reproductive bodies.
- Symbiosis*.—The living together of dissimilar organisms, both contributing to their mutual welfare. It differs from parasitism in which the benefit is all on the side of the parasitic organism.
- Teleutospore*.—Generally regarded as the final spore in the life cycle of the Rusts, which germinates and produces a promycelium and promycelial spores.
- Truncate*.—Cut off abruptly.
- Uredo*.—The generic name originally applied to the uredospores.
- Uredospore*.—A spore detached from the apex of a pedicel and producing a mycelium.
- Verrucose*.—Covered with small warts.
- Witches' broom*.—A diseased state of the shoots of a plant, when they are developed in tangled masses or tufts, due to parasitic agencies and especially fungi.

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PLATE A.

(All Figures nat. size.)

PUCCINIA TRITICINA ON WHEAT.

Fig.

1. Uredosori on upper surface of leaf.
2. Teleutosori on under surface.

PUCCINIA GRAMINIS ON WHEAT.

3. Uredosori on upper and under surface, also on sheath.
4. Teleutosori on stem.



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WHEAT RUST.

PLATE B.

(All Figures nat. size.)

PUCCINIA LOLII AVENAE ON OATS.

Fig.

5. Uredosori on under surface of leaf.
6. Teleutosori on under surface

PUCCINIA LOLII ON RYE-GRASS.

7. Uredosori on under surface of leaf.
8. Teleutosori on upper surface.

PUCCINIA SIMPLEX ON BARLEY.

9. Teleutosori on sheath and blade.
10. Uredosori on under surface of leaf.



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PLATE C.

*(All Figures nat. size.)*PUCCINIA BROMINA ON SOFT BROME (*Bromus mollis*).

Fig.

- 11. Uredosori on under surface of leaf.
- 12. Teleutosori on under surface.
- 13. Teleutosori on stem.

PUCCINIA MAYDIS ON MAIZE (*Zea mays*).

- 14. Uredosori on under surface of leaf.
- 15. Teleutosori on young stem.

PUCCINIA THUEMENI ON CELERY (*Apium graveolens*).

- 16. Uredosori on upper surface of leaf.
- 17. Uredosori on under surface.



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BROME-GRASS, MAIZE, AND CELERY RUSTS.

PLATE D.

*(All Figures nat. size.)*PUCCINIA CICHORII ON CHICORY (*Cichorium intybus*).

Fig.

18. Chiefly uredosori on lower surface of chicory leaf.

PUCCINIA PRUNI ON PEACH AND APRICOT (*Prunus persica* and
P. armeniaca).

19. Uredo and teleutosori on lower surface of peach leaf.

20. Uredo and teleutosori on lower surface of apricot leaf.



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CHICORY, PEACH, AND APRICOT RUSTS.

PLATE E.

(All Figures nat. size.)

PUCCINIA CHRYSANTHEMI ON CHRYSANTHEMUM.

Fig.**21.** Uredosori on under surface of leaf.PUCCINIA CALENDULAE ON MARIGOLD (*Calendula officinalis*).**22.** Aecidia and teleutosori on under surface of leaf.**23.** Uredo and teleutosori on stem.

PUCCINIA HEDERACEAE ON NATIVE VIOLETS.

24. Uredo and teleutosori on under surface of leaf of *Viola hederacea***25.** Aecidia on under surface of leaf of *V. betonicifolia*.PUCCINIA DISTINCTA ON DAISY (*Bellis perennis*)**26.** Aecidia and teleutosori on upper surface of leaf, showing the dark teleutosori surrounding the other.



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CHRYSANTHEMUM, MARIGOLD, VIOLET, AND DAISY RUSTS.

PLATE F.

(All Figures nat. size.)

PUCCINIA LAGENOPHORAE ON LAGENOPHORA BILLARDIERI.

Fig.

27. Aecidia and teleutosori on both surfaces of leaves.

PUCCINIA MALVACEARUM ON LAVATERA PLEBEIA.

28. Teleutosori on under surface of leaf and on leaf-stalk.

PUCCINIA MORRISONI ON PELARGONIUM AUSTRALE.

29. Aecidia, uredo, and teleutosori on under surface of leaf, and teleutosori on stem.



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PLATE G.

(All Figures nat. size.)

UROMYCES CARYOPHYLLINUS ON CARNATION (Dianthus caryophyllus).

Fig.

30. Uredosori on upper surface of leaf.

31. Teleutosori on both surfaces.

UROMYCES TRIFOLII ON WHITE CLOVER (Trifolium repens).

32. Aecidia, uredo, and teleutosori on leaf.

UROMYCES VESICULOSUS ON ZYGOPHYLLUM GLAUCESCENS.

33. Uredo and teleutosori on both surfaces of leaves and on stems.

UROMYCES HARDENBERGIAE ON HARDENBERGIA MONOPHYLLA.

34. Uredosori on under surface of leaf.

30

31

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33

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CARNATION, CLOVER, AND OTHER RUSTS.

PLATE H.

*(Natural Size.)*UROMYCES BETAE ON MANGEL (*Beta vulgaris*).

Fig.

35. Uredo and teleutosori on under surface of leaf.

This leaf was obtained from Mangels, the roots of which had been planted in August for seed, and in January the plants were fully six feet high, with abundance of foliage covered on both sides with rust.



35

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L. latifolia

R.S. Brown, Sculp. & Print.

MANGEL RUST.

PLATE I.

(All Figures nat. size.)

MELAMPSORA LINI ON NATIVE FLAX (*Linum marginale*).

Fig.

36. Uredo and teleutosori on stem.

PHRAGMIDIUM SUBCORTICIUM ON SWEET-BRIER (*Rosa rubiginosa*).

37. Aecidia (*Caeomata*) showing large swollen patches on stems and small patches on lower surface of leaves.

PHRAGMIDIUM BARNARDI ON NATIVE RASPBERRY (*Rubus parvifolius*).

38. Ochraceous uredosori on lower surface of leaves and flower-stalks, powdery teleutosori accompanying uredosori.



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R.S. Brain, Govt. Printer

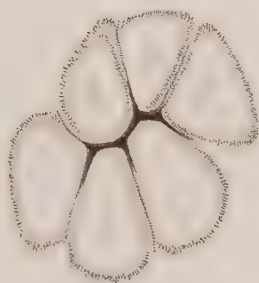
SWEET BRIAR, RASPBERRY, AND FLAX RUSTS.

PLATE J.

AECIDIUM ON DANTHONIA.

Fig.

39. Leaves with aecidia in dense clusters	...	...	...	nat. size
40. Cluster of aecidia on leaf	...	...	...	... × 15
41. Section of aecidium showing peridial wall and spores in chains	...	...	...	... × 50
42. Chain of aecidiospores	...	...	...	... × 1000
43. Single spore detached and more or less rounded	...	...	...	... × 1000
44. Pseudoperidial cells seen from the surface × 550



C.C. Brattlebank, Del.

D.M. Alpine, Duxbury

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PLATE I.

(All Figures $\times 250$ unless otherwise stated.)

PUCCINIA.

Fig.

1. Portion of sheath of barley (*Hordeum vulgare*) showing numerous crowded black dots, the teleutosori of *Puccinia simplex*, the spring or orange rust of barley nat. size
2. Portion of sheath of wheat (*Triticum vulgare*), the broad dark lines representing the uredosori of *P. graminis*, summer rust of wheat nat. size
3. Portion of flag of wheat, the small dark dots representing the uredo and teleutosori of *P. triticea*, the spring or orange rust of wheat ... nat. size
4. Uredospores of *P. simplex* from barley, the numerous germ pores appearing as paler dots scattered promiscuously over the face of the spore.
5. Uredospores of *P. graminis* from wheat, with their three equatorial germ pores.
6. Uredospores of *P. triticea* from wheat with germ pores promiscuously scattered over the face.
7. Teleutospores of *P. graminis* from wheat, the thickened apex being very pronounced.
8. Teleutospores of *P. graminis* from wheat, upper cells checked in their development by some unknown cause as shown by their pale colour, not due to germination having already occurred.
9. Teleutospores of *P. simplex* from barley, only one being two-celled.
10. Section of teleutosorus of *P. triticea* on wheat, with paraphyses at left.

NOTE.—The whole of the photomicrographs in this and the succeeding plates were taken with the horizontal laboratory camera made by Messrs. Watson and Sons, of London, using their Holoscopic lens of 12 mm. .65 N.A. to obtain the magnification of 250 diams., and the 6 mm. .95 N.A. for 500 diams.



G. H. Robinson, Phot.

Nat. size and $\times 250$.

PUCCINIA.
GRAMINEAE.

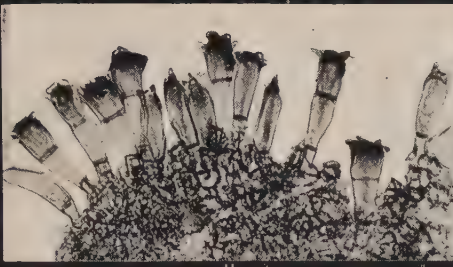
PLATE II.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

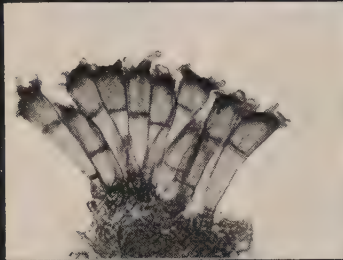
11. Section of teleutosorus of *Puccinia lolii avenae* on oat (*Avena sativa*) with several unicellular as well as bicellular teleutospores.
12. Group of teleutospores of *P. beckmanniae* on *Beckmannia erucaeformis*.
13. Section of teleutosorus of *P. festucae* on *Festuca pratensis*.
14. Section of teleutosorus of *P. lolii* on *Lolium perenne*.
- 15, 16. Groups of teleutospores of *P. maydis* on *Zea mays*, including one four-celled spore.
17. Teleutospores of *P. flavescentis* on *Stipa flavescentis*.
18. Section of teleutosorus of *P. magnusiana* on *Phragmites communis*.
19. Five teleutospores of *P. tepperi* on *Phragmites communis*, showing the extremely long pedicels.



11



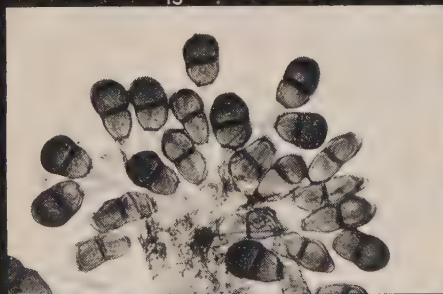
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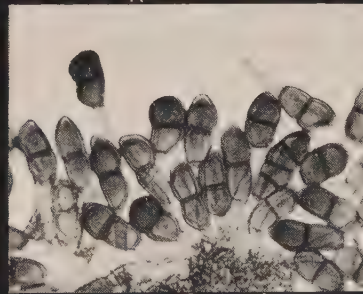
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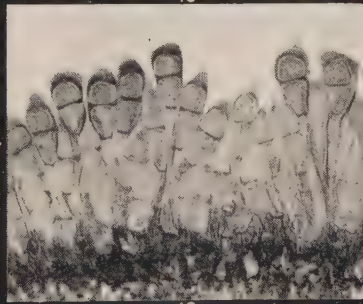
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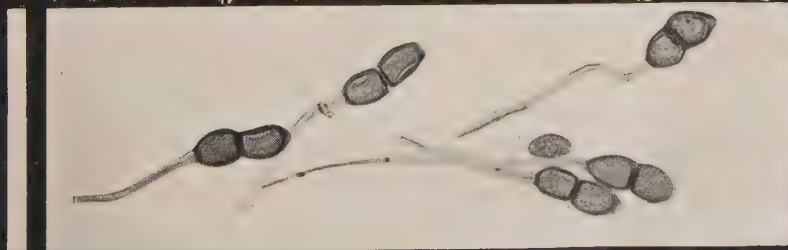
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PLATE III.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

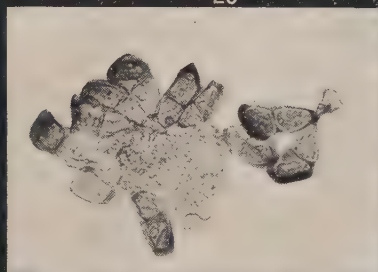
20. Section of teleutosorus of *Puccinia anthoxanthi* on *Anthoxanthum odoratum*, one spore with a septate pedicel laterally inserted.
21. Group of teleutospores of the same, one with a much inflated pedicel.
22. Teleutospores of *P. poarum* on *Poa annua*.
23. Teleutospores of *P. perplexans* on *Alopecurus geniculatus*.
24. Teleutospores of *P. cynodontis* on *Cynodon dactylon*.
25. Section of teleutosorus of *P. agropyri* on *Agropyron scabrum*.
26. Group of teleutospores of *P. impatientis* on *Elymus condensatus*.
27. Group of teleutospores of *P. agrostidis* on *Deyeuxia forsteri*.
28. Section of teleutosorus of *P. bromina* on *Bromus mollis*.



20



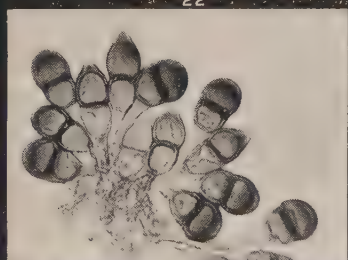
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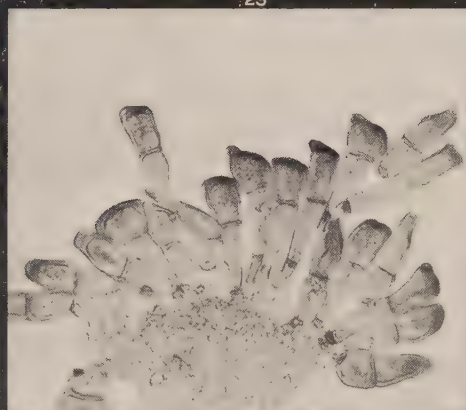
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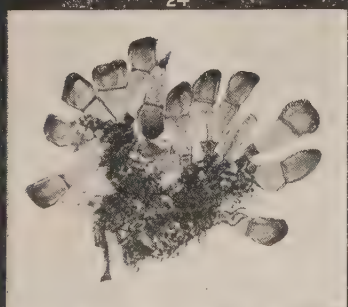
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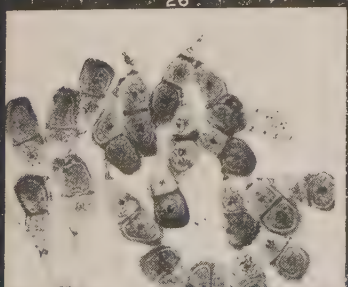
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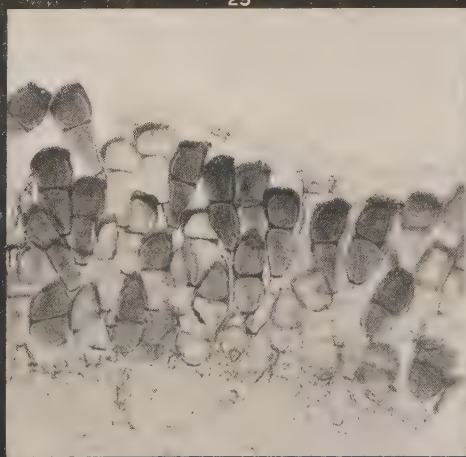
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G. H. Robinson, Phot.

× 250

PUCCINIA.
GRAMINEAE.

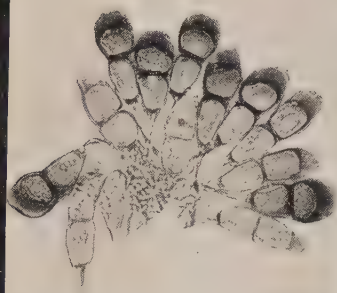
PLATE IV.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

29. Group of teleutospores of *Puccinia caricis* on *Carex breviculmis*, Killara, Victoria.
30. Group of teleutospores of *Puccinia caricis* on *Carex stricta*, Berlin, Germany (Sydow, Uredineen, 460).
31. Teleutospores of *P. longispora* on *Carex caespitosa*.
32. Teleutospores of *P. cyperi* on *Cyperus rotundus*.
33. Group of teleutospores of *P. tenuispora* on *Luzula campestris*, Murramurrangbong Ranges, Victoria.
34. Teleutospores of *P. obscura* on *Luzula campestris*, Berlin, Germany (Sydow, Uredineen, 1076). The spores of this species are differently shaped, much thicker in the wall and much darker than those of *P. tenuispora*.
35. Uredospores of *P. juncophila* from sorus containing both uredo and teleutospores on *Juncus maritimus*.
36. Teleutospores of the same.



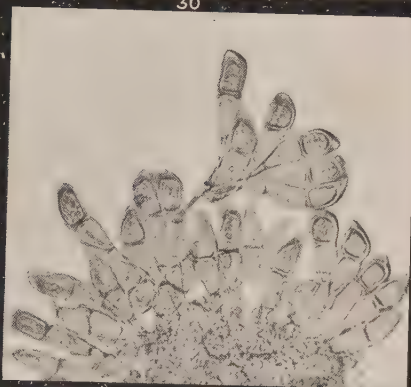
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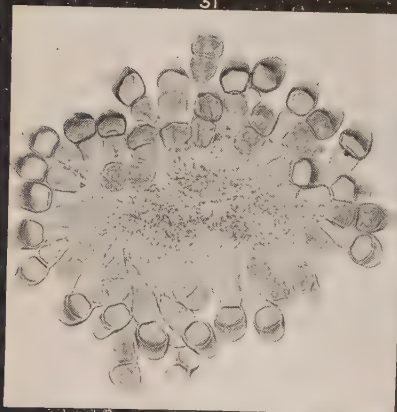
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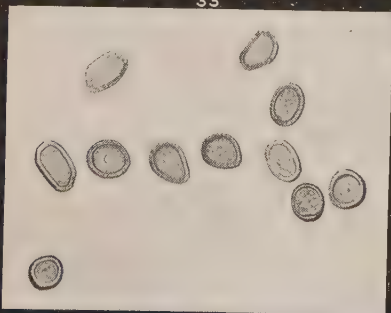
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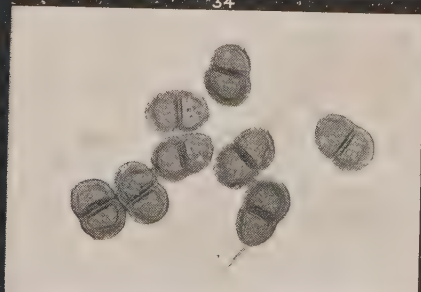
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G. H. Robinson, Phot.

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PUCCINIA.
CYPERACEAE AND JUNCACEAE.

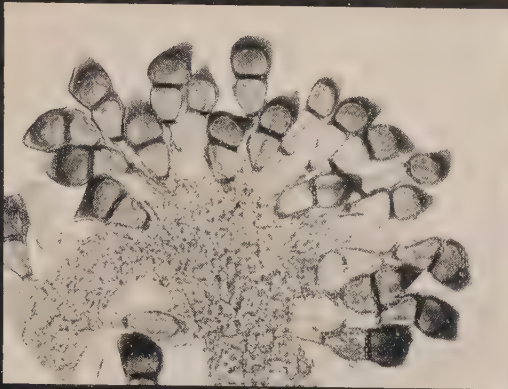
PLATE V.

(All Figures $\times 250$.)

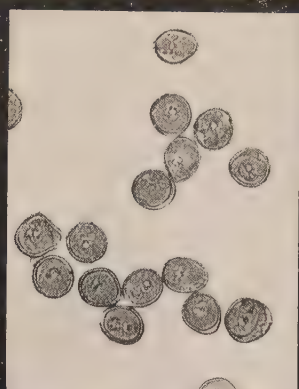
PUCCINIA.

Fig.

37. Teleutospores and mesospores of *Puccinia wurmbeae* on *Wurmbea dioica*
38. Uredospores of *P. burchardiae* on *Burchardia umbellata*.
39. Teleutospores, one three-celled, of the same.
40. Teleutospores and mesospores of *P. haemodori* on *Haemodorum* sp.
41. Teleutospores and mesospores of *P. hypoxidis* on *Hypoxis glabella*.
42. Teleutospores, two three-celled, of *P. dichondrae* on *Dichondra repens*.
43. Teleutospore and uredospore of *P. mussoni* on *Ruellia australis*, Richmond River, New South Wales.
44. Teleutospores of *P. ruelliae* on *Ruellia strepens*, Columbus, Ohio, U.S.A. (W. A. Kellerman, Ohio Fungi, 130).



37



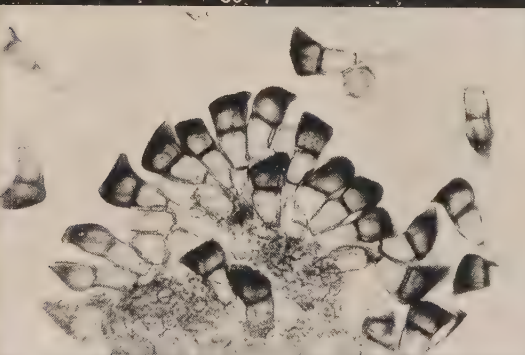
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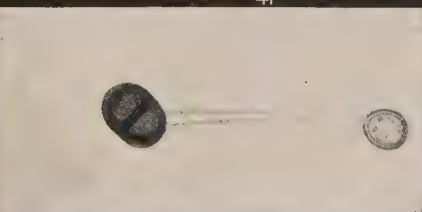
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G. H. Robinson, Phot.

× 250.

PUCCINIA.

LILIACEAE, HAEMODORACEAE, AMARYLLIDEAE, AND ACANTHACEAE.

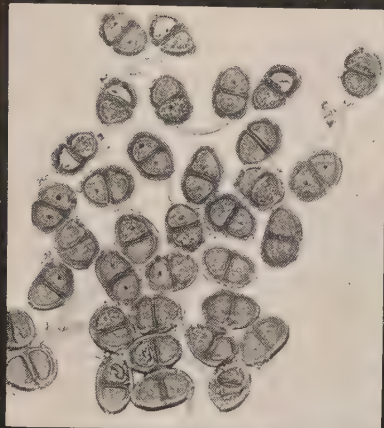
PLATE VI.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

45. Group of teleutospores of *Puccinia carissae* on *Carissa ovata*.
46. Section of teleutosorus of *P. alyxiae* on *Alyxia buxifolia*, with teleutospores and mesospores.
47. Teleutospores of *P. gilgiana* on *Leschenaultia linarioides*.
- 48, 49. Teleutospores and mesospores of *P. saccardoi* on *Goodenia geniculata*.
50. Teleutospores and mesospores of *P. brunoniae* on *Brunonia australis*, with one three-celled and one four-celled teleutospore.
51. Teleutospores of *P. aucta* on *Lobelia anceps*. (From a drawing by C. C. Brittle-bank from the original material from Berkeley in the National Herbarium, Melbourne).



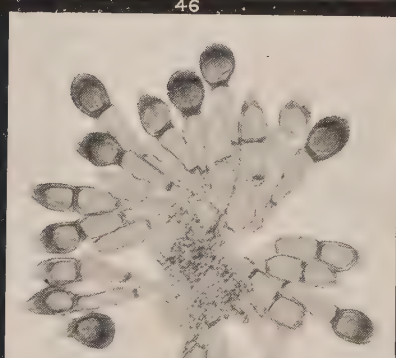
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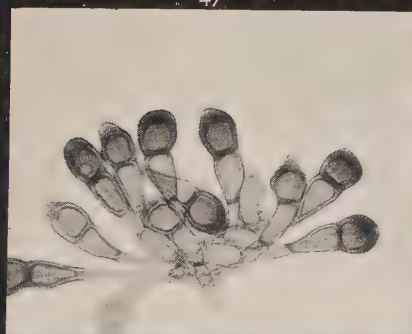
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47



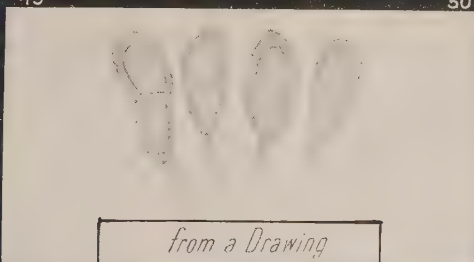
48



49



50



from a Drawing

51

PLATE VII.

(All Figures $\times 250$.)

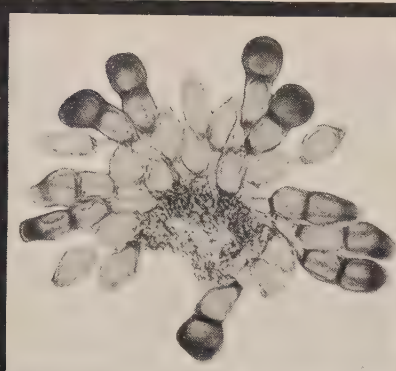
PUCCINIA.

Fig.

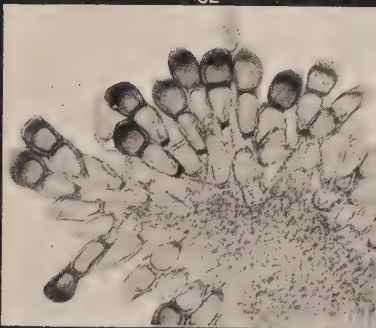
52. Teleutospores and mesospores of *Puccinia tasmanica* on *Senecio vulgaris*, one teleutospore being three-celled.
53. Teleutospores and mesospores of *P. angustifoliae* on *Scorzonera angustifolia*.
- 54, 55. Sections of teleutosori of *P. lagenophorae* on *Lagenophora billardieri*, showing mesospores and teleutospores.
56. Teleutospores and mesospores of *P. helianthi* on *Helianthus annuus*.
57. Teleutospores of *P. gnaphalii* on *Gnaphalium japonicum*.
58. Teleutospores and mesospores of *P. calocephali* on *Calocephalus drummondii*.
59. Teleutospores and mesospores of *P. erechitidis* on *Erechtites quadridentata*.



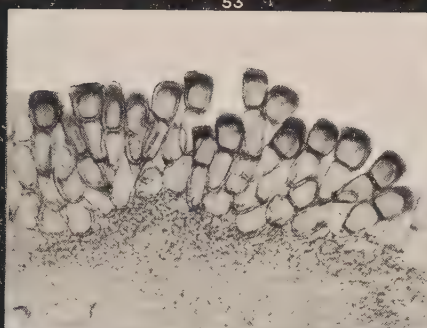
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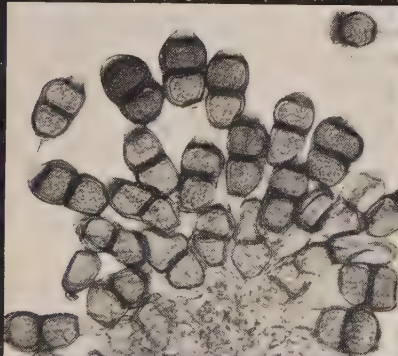
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54



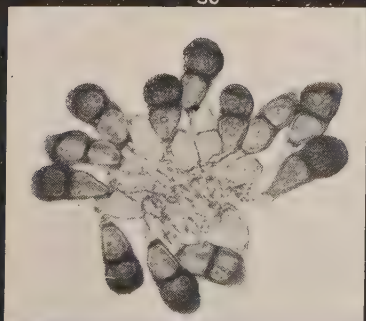
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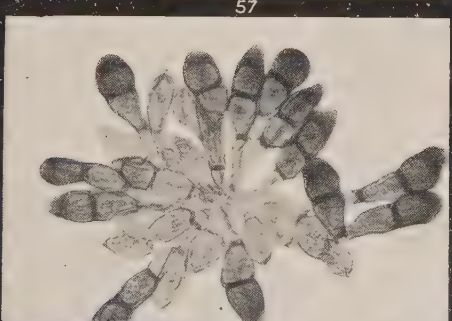
56



57



58



59

G. H. Robinson, Phot.

× 250.

PUCCINIA.
COMPOSITAE.



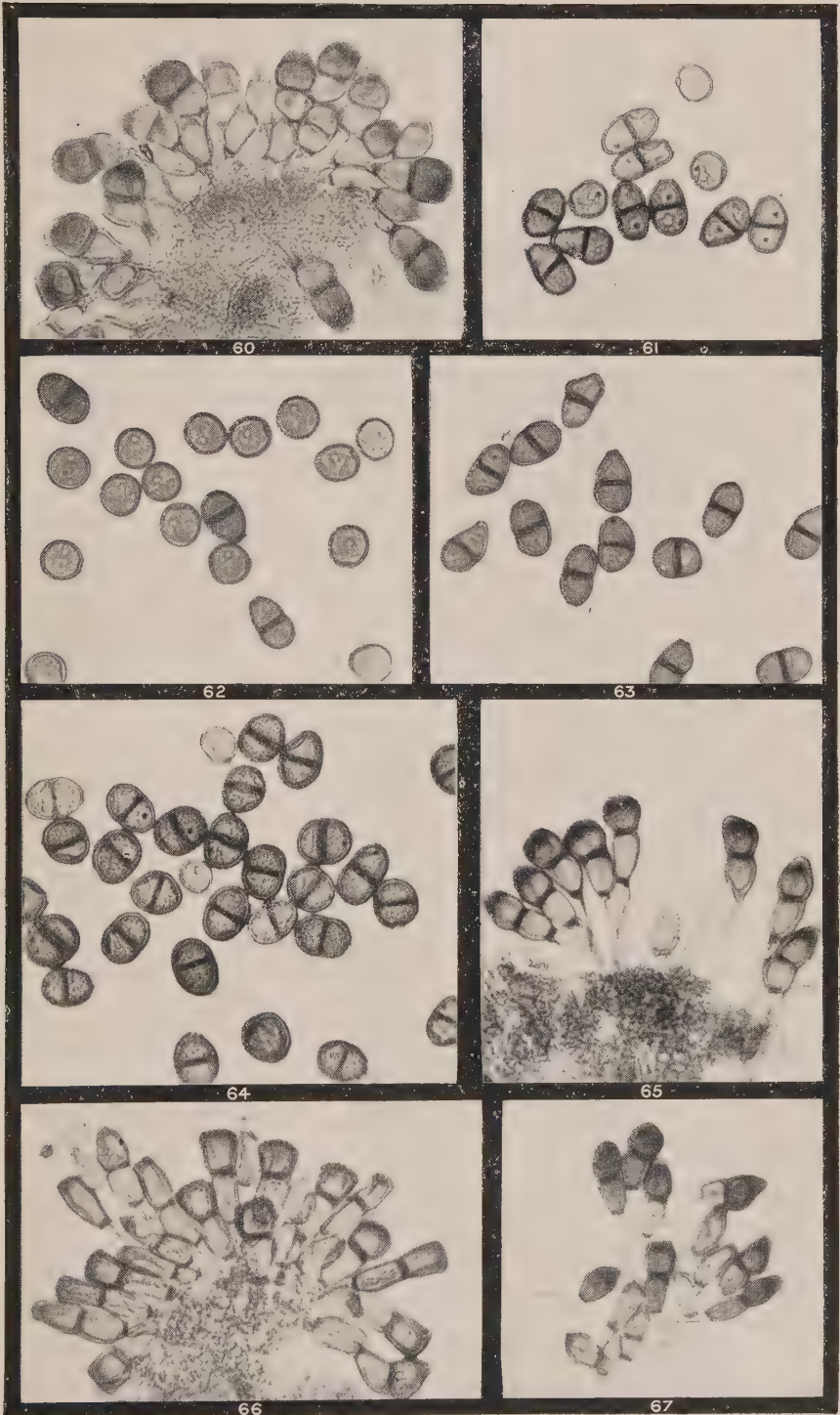
PLATE VIII.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

60. Section of teleutosorus of *Puccinia cinerariae* on *Cineraria* sp. cult. with teleutospores and mesospores.
61. Three uredospores and several teleutospores of *P. cichorii* on *Cichorium intybus*.
62. Uredospores and teleutospores of *P. hypochoeridis* on *Hypochoeris radicata*.
63. Teleutospores of the same.
64. Two uredospores and numerous teleutospores of *P. cyani* on *Centaurea cyanus*.
65. One mesospore and several teleutospores of *P. calendulae* on *Calendula officinalis*.
66. Mesospores and teleutospores of *P. brachycomes* on *Brachycome ciliaris*.
67. Teleutospores and mesospores of *P. distincta* on *Bellis perennis*.



C. H. Robinson, Phot.

× 250

PUCCINIA.
COMPOSITAE.

PLATE IX.

(All Figures $\times 250$ unless otherwise stated.)

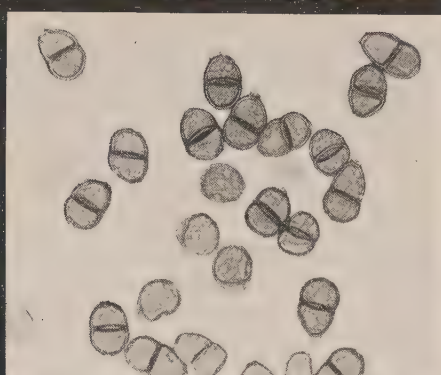
PUCCINIA.

Fig.

68. Three uredospores and four teleutospores of *Puccinia thucmeni* on *Apium pteristratum*, showing thickened apex of uredospore and slight warting of teleutospore. Beaumaris, Victoria.
69. Uredospores and teleutospores from same, but in greater variety.
70. One uredospore and two teleutospores from the same, but more highly magnified, and showing more clearly the roughened episporium of both uredo and teleutospores ... $\times 500$
71. Teleutospores of *P. thucmeni* on *Apium graveolens*, from Brighton, Victoria.
72. Uredospore and teleutospore from the same as 71, showing roughened episporium in both forms more clearly ... $\times 500$
73. Uredospores and teleutospores of *P. apii* on *Apium graveolens*, Berlin, Germany. (Sydow, Uredineen, 558.)
74. Teleutospores as in Fig. 73, showing distinctly smooth episporium ... $\times 500$
75. Teleutospores of *P. bullata* on *Arctostaphylos uva-ursi*, with coarsely warted episporium. (Sydow, Uredineen, 1261.) ... $\times 500$
76. Teleutospores of *P. xanthosiae* on *Xanthosia pusilla*.



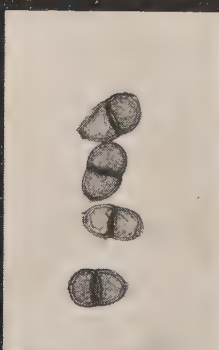
68



69



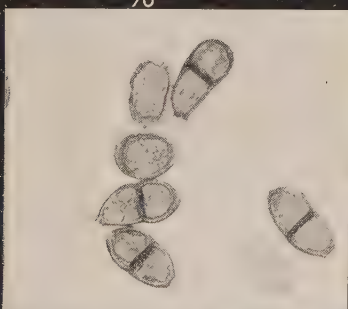
70



71



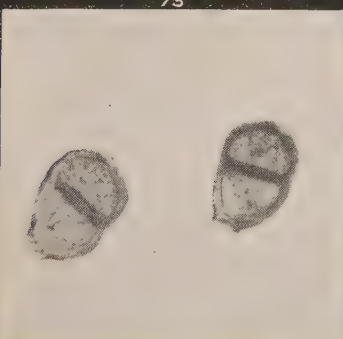
72



73



74



75



76

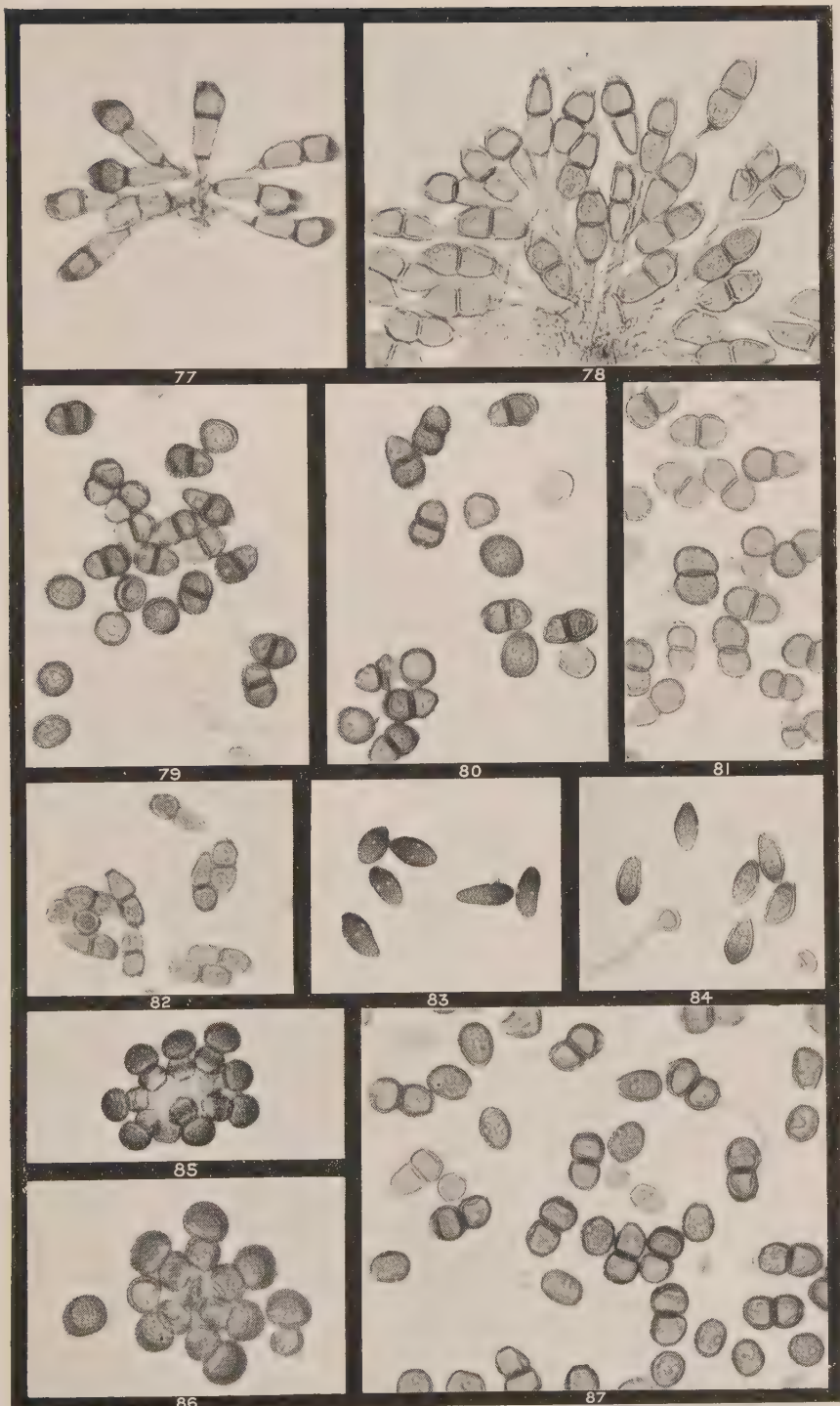
PLATE X.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

77. Teleutospore of *Puccinia oliganthae* on *Asperula oligantha*.
78. Teleutospores, some having germinated, of *P. coprosmae*, on *Coprosma hirtella*.
79. Uredospores and teleutospores of *P. epilobii-tetragoni* on *Epilobium glabellum*, Murramurrangbong Ranges, Victoria.
80. Uredospores and teleutospores of *P. epilobii-tetragoni* on *Epilobium montanum*. (Sydow, Uredineen, 1369.)
81. Teleutospores of *P. epilobii* DC. on *Epilobium roseum*, the teleutospores having much thinner walls, and being more variable in shape than those of *P. epilobii-tetragoni* and also finely verrucose. (Sydow, Uredineen, 1418.)
82. Teleutospores of *P. gei* on *Geum renifolium*.
83. Uredospores of *P. pruni* on *Prunus persica*.
84. Paraphysis and uredospores of *P. pruni* on *Prunus persica*.
85. Teleutospores of *P. pruni* on *Prunus persica*, rather smaller than average.
86. Teleutospores of *P. pruni* on *Prunus domestica*.
87. Uredospores and teleutospores of *P. zorniae* on *Zornia diphylla*.



G. H. Robinson, Phot.

× 250.

PUCCINIA.

RUBIACEAE, ONAGRACEAE, ROSACEAE, AND LEGUMINOSAE.

PLATE XI.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

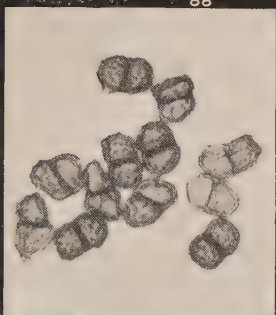
- 88, 89. Teleutospores of *Puccinia tetragoniae* on *Tetragonia implexicoma*, one with nearly vertical septum in upper cell.
90. Teleutospores, strongly warted, of *P. ludwigii* on *Rumex flexuosus*.
91. Teleutospores strongly warted, of *P. ludwigii* on *Rumex brownii*, one spore being *Triphragmium*-like.
92. Uredospore and teleutospores of *P. acetosae* on *Rumex arifolius*, all the latter with smooth walls. (Sydow, Uredineen, 954.)
93. Teleutospores of *P. muehlenbeckiae* on *Muehlenbeckia adpressa*.
94. Teleutospores and mesospore of *P. dielsiana* on *Threlkeldia* sp.
95. Uredospores of *P. kochiae* on *Kochia sedifolia*, showing the characteristic numerous germ pores.
96. Teleutospores of *P. kochiae* on *Kochia sedifolia*.



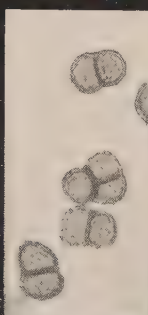
88



89



90



91



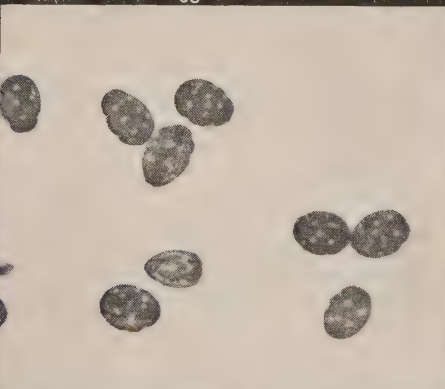
92



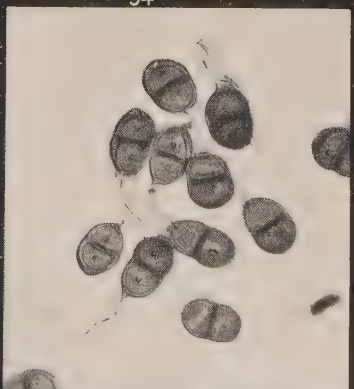
93



94



95



96

G. H. Robinson, Phot.

× 250.

PUCCINIA.
FICOIDEAE, POLYGONACEAE, AND OHENOPODIACEAE.

PLATE XII.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

97. Teleutospores of *Puccinia arenariae* on *Stellaria media*.
98. Teleutospores of *P. plagianthi* on *Plagianthus sidoides*, the epispore being slightly channelled.
99. Teleutospores (stained) of *P. malvacearum* on *Malva rotundifolia*.
100. Teleutospores and mesospore of *P. malvacearum* on *Lavatera plebeia*.
101. Teleutospores, mostly one-celled, of *P. heterospora* on *Abutilon crispum*.
102. Teleutospores and mesospores of *P. morrisoni* on *Pelargonium australe*.
103. Uredospores of *P. geranii-pilosi* on *Geranium pilosum*.
104. Teleutospores of the same, the single germ pore being noticeable as a paler channel through the apex of the cell wall.



97



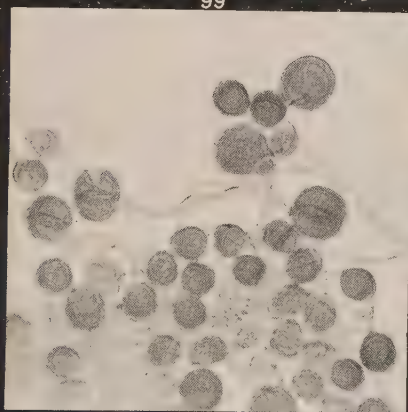
98



99



100



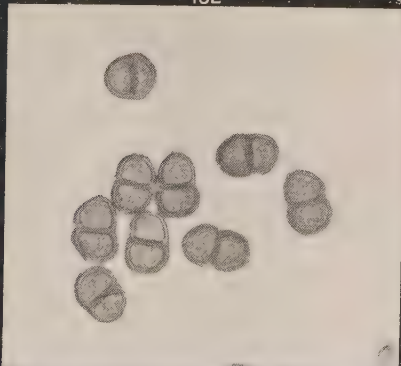
101



102



103



104

G. H. Robinson, Phot.

× 250.

PUCCINIA.

CARYOPHYLLACEAE, MALVACEAE, AND GERANIACEAE.

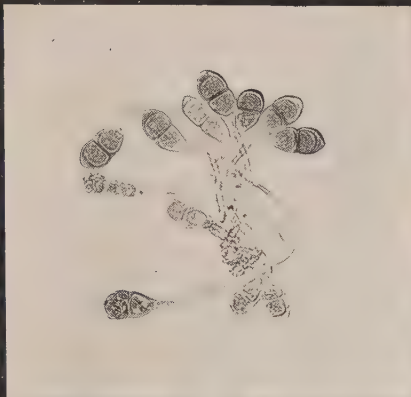
PLATE XIII.

(All Figures $\times 250$ unless otherwise stated.)

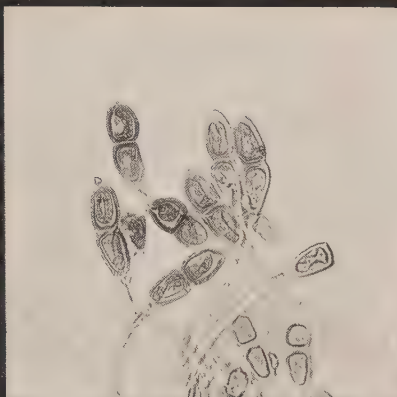
PUCCINIA.

Fig.

105. Teleutospores of *Puccinia eriostemonis* on *Eriostemon myoporoides*.
106. Teleutospores of *P. correae* on *Correa lawrenciana*.
107. Teleutospores and mesospores of *P. boroniae* on *Boronia spinescens*.
108. Teleutospores and mesospores of *P. pritzeliana* on *Tremandra stelligera*, some teleutospores having germinated.
109. Teleutospores of *P. hederaceae* on *Viola hederacea*.
110. Teleutospores of the same, more highly magnified, to show more clearly the slightly warted epispore $\times 500$
111. Teleutospore of *P. aegra* on *Viola tricolor* with smooth epispore. (W. B. Grove in Rabh. Fungi Europaei, 3113) $\times 500$
112. Teleutospores of *P. violae* on *Viola arenaria*, with smooth epispore. (Sydow, Uredineen, 286) $\times 500$



105



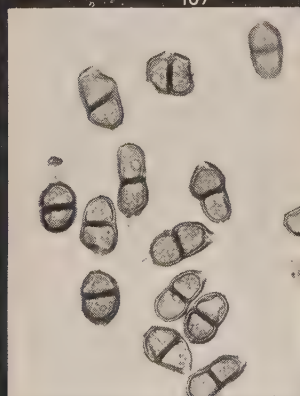
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107



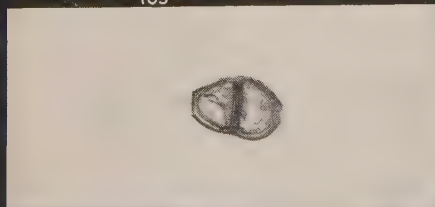
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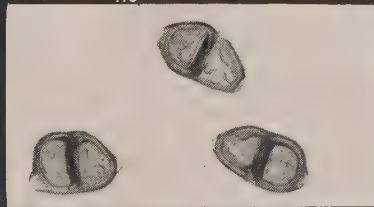
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110



111



112

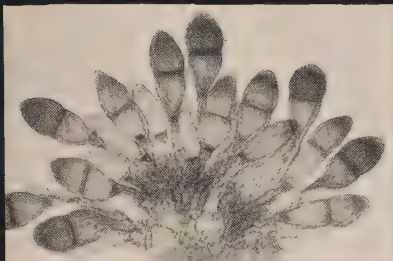
PLATE XIV.

(All Figures $\times 250$.)

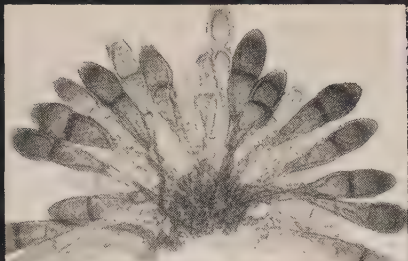
PUCCINIA GRAMINIS ON VARIOUS GRASSES.

Fig.

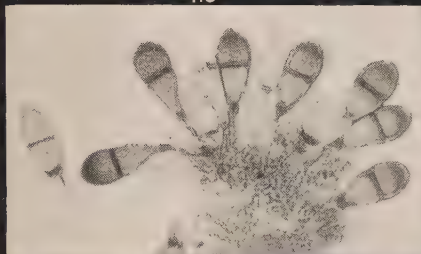
113. Teleutospores and mesospores on wild oat, *Avena fatua*.
114. Teleutospores on barley, *Hordeum vulgare*.
- 115, 116. Teleutospores, mesospores, and uredospore, one of the first three-celled, on native barley, *Echinopogon ovatus*.
117. Teleutospores on cocksfoot, *Dactylis glomerata*.
118. Teleutospores and uredospores on silver grass, *Festuca bromoides*.
119. Teleutospores and uredospores on an imported barley grass, *Hordeum secalinum*.
120. Teleutospores on small canary-seed grass, *Phalaris minor*.
121. Teleutospores on native wheat grass, *Agropyron scabrum*.
122. Teleutospores on *Amphibromus neesii*.



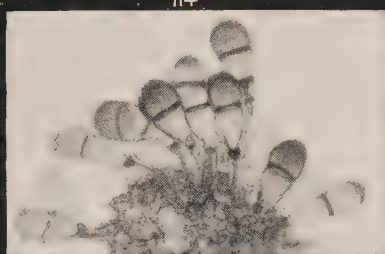
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114



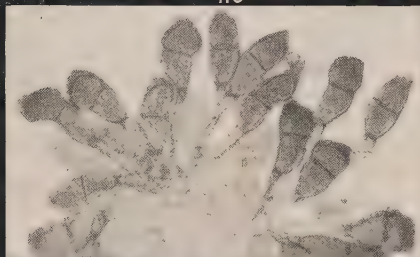
115



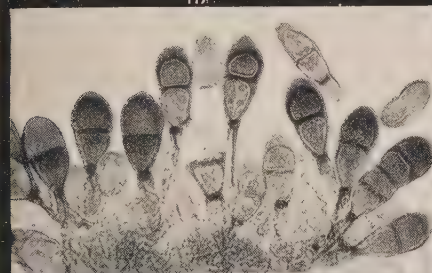
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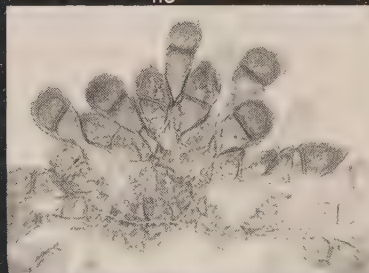
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118



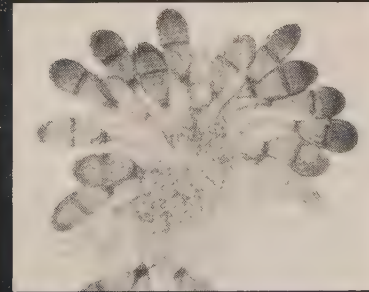
119



120



121



122

G. H. Robinson, Phot.

X 250.

PUCCINIA GRAMINIS ON VARIOUS GRASSES.

PLATE XV.

(All Figures $\times 250$ unless otherwise stated.)

GERMINATION OF TELEUTOSPORES OF PUCCINIA MALVACEARUM.

Fig.

123. Germinating teleutospore, from each cell of which a promycelium has been pushed forth, cell contents collected towards apex of tube, and segmentation commenced.
124. Germinating teleutospore at a later stage, the promycelium having become divided into four segments, and comparatively stout tubes emitted from each segment.
125. Two germinating teleutospores, in the one on the left only the two median segments of the promycelium as yet bear sporidiola.
126. Germinating teleutospore with stout elongated and contorted filaments arising from the promycelial cells, those from the two median cells ultimately giving rise to abnormally small sporidiola.
127. Germinating teleutospore in which the upper two promycelial cells have produced sporidiola, while in the third from the apex the formation of the sporidiolum is just commencing.
128. Germinating teleutospore, the promycelium bearing three sporidiola on stout elongated sterigmata. The sporidiolum second from the base is already germinating and putting forth a germ tube extending across to the promycelium. The segment second from the apex has not so far produced a sporidiolum, though a stout elongated filament has been emitted.
129. Promycelial spores $\times 500$
130. Germinating promycelial spore , $\times 500$

NOTE.—All the above were grown in droplets of water on slides in a moist chamber, and prepared for photographing by being first dried, then fixed with a saturated solution of mercuric bichloride, washed, rinsed in dilute acetic acid, washed again, and after drying stained with alcoholic Bismarck brown, again washed and mounted in glycerine and water.



G. H. Robinson, Phot.

× 250 & 500.

Puccinia.
TELEUTOSPORE GERMINATION OF *P. MALVACEARUM*.

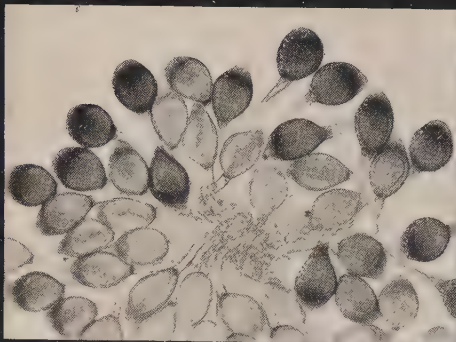
PLATE XVI.

(All Figures $\times 250$.)

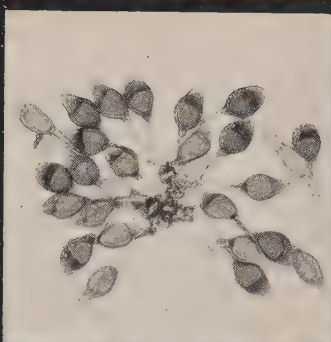
UROMYCES. ~

Fig.

131. Group of teleutospores of *Uromyces danthoniae* on *Danthonia semiannularis*.
132. Teleutospores of *U. ehrhartae* on *Microlaena (Ehrharta) stipoides*.
133. Teleutospores of *U. tenuicutis* on *Sporobolus indicus*.
134. Two one-celled and one two-celled teleutospore of *U. tricorynes* on *Tricoryne elatior*.
135. Teleutospores of *U. tricorynes* on *Tricoryne elatior*.
136. Uredospores of *U. thelymitrae* on *Thelymitra antennifer*.
137. Teleutospores of the same.
138. Teleutospores of *U. orchidearum* on *Chiloglottis diphylla*, from original type material in National Herbarium.
139. Teleutospores of *U. microtidis* on *Microtis porrifolia* from type material from Massee.



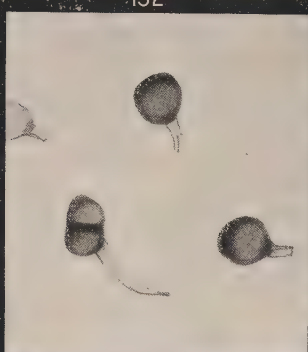
131



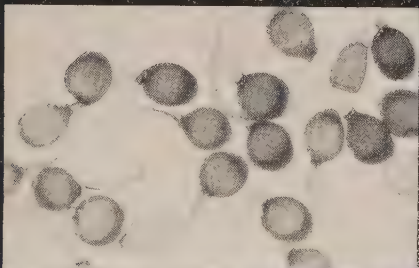
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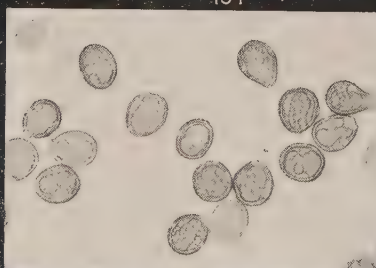
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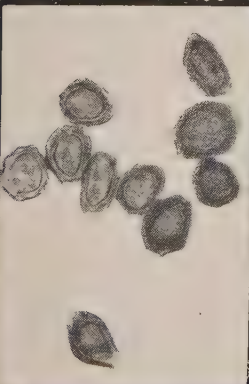
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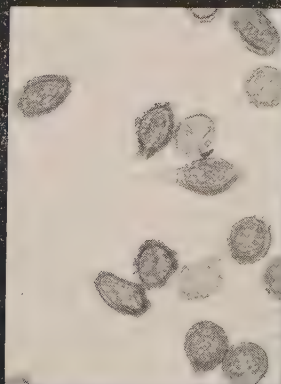
135



136



137



138



139

G. H. Robinson, Phot.

X 250

UROMYCES.
GRAMINEAE, LILIACEAE AND ORCHIDACEAE.

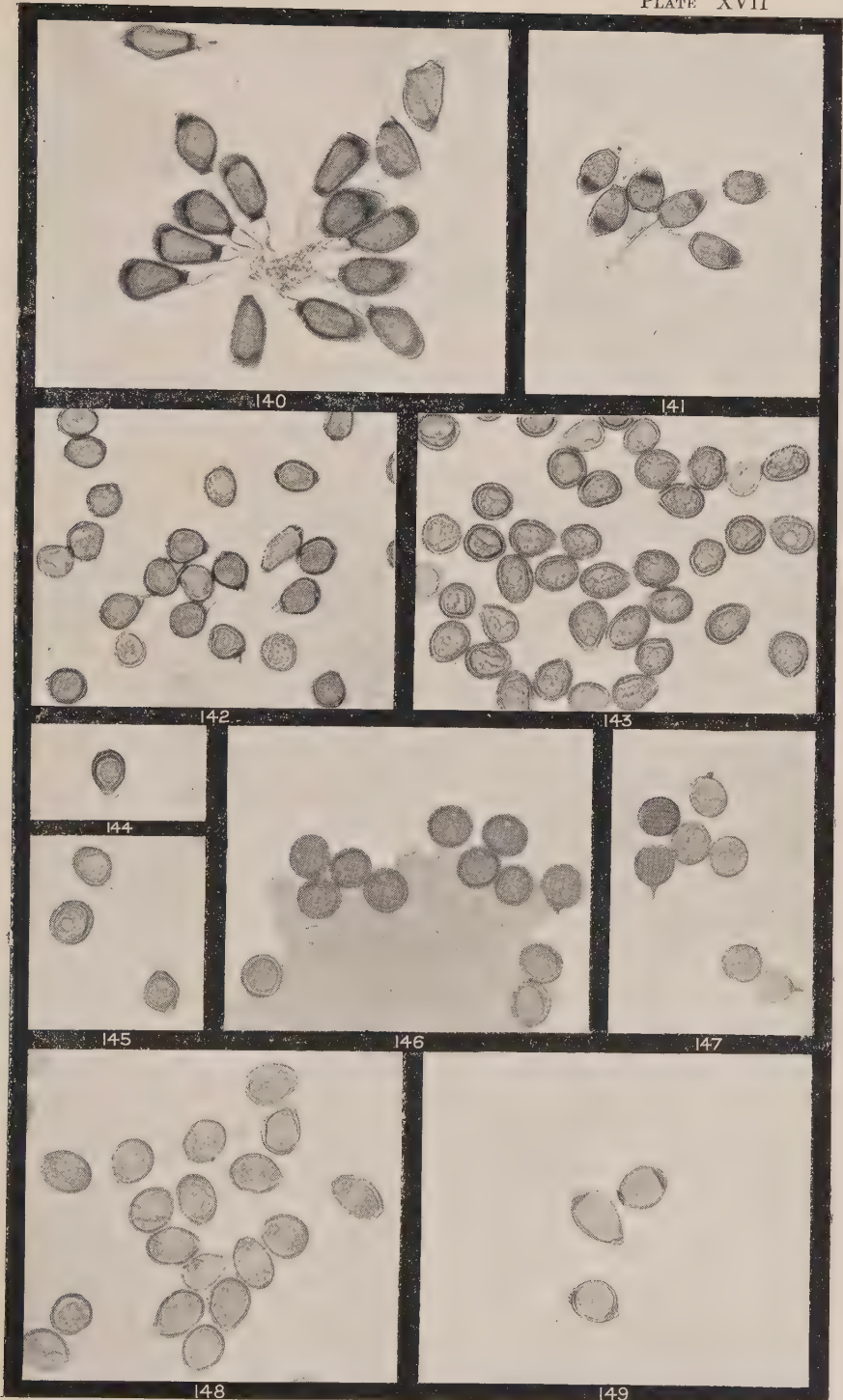
PLATE XVII.

(All Figures $\times 250\times$)

UROMYCES.

Fig.

140. Group of teleutospores of *Uromyces puccinioides* on *Selliera radicans*.
141. Teleutospores of *U. asperulae* on *Asperula oligantha*.
142. Uredospores and teleutospores of *U. trifolii* on *Trifolium repens*.
143. Uredospores of *U. hardenbergiae* on *Hardenbergia monophylla*.
144. Teleutospore of the same.
145. Two uredospores of same at top and one teleutospore below.
146. Section of teleutosorus of *U. atriplicis* on *Atriplex semibaccata* The teleutospores are faintly striate with one prominent germ pore at apex.
147. Two teleutospores of same at left and four uredospores at right.
148. Uredospores of *U. betae* on *Beta vulgaris*.
149. Teleutospores of same with prominent hyaline apiculus.



G. H. Robinson, Phot.

X 50.

UROMYCES.

GOODENIACEAE, RUBIACEAE, LEGUMINOSAE, AND CHENOPODIACEAE.

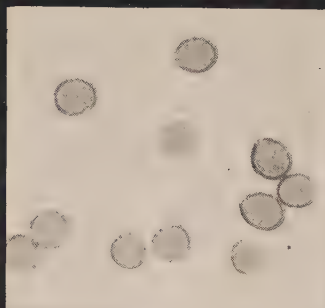
PLATE XVIII.

(All Figures $\times 250$ unless otherwise stated.)

UROMYCES.

Fig.

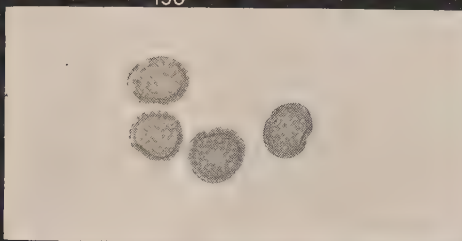
150. Uredospores of *Uromyces polygoni* on *Polygonum aviculare*.
151. Teleutospores of same.
152. Uredospores of *U. caryophyllinus* on *Dianthus caryophyllus*, with prominent scattered germ pores.
153. Teleutospores and one uredospore of same.
154. Section through leaf of *Dianthus caryophyllus*, showing uredosorus of *U. caryophyllinus* with two pycnidia of *Darluca filum* growing upon it, and two young pycnidia on opposite surface of leaf $\times 50$
155. Uredospores of *U. vesiculosus* on *Zygophyllum glaucescens*.
156. Teleutospores of same.
157. Two-celled teleutospore of same.



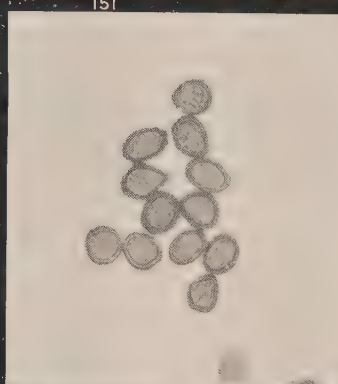
150



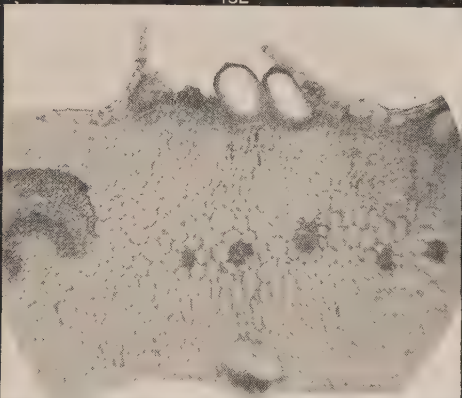
151



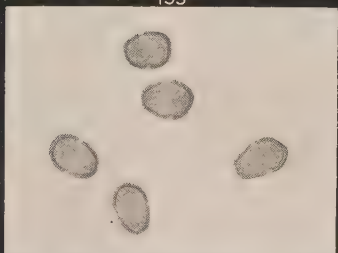
152



153



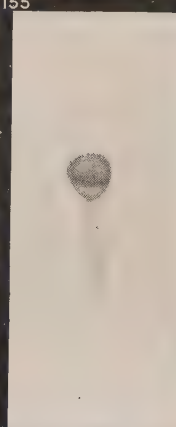
154



155



156



157

G. H. Robinson, Phot.

X 50 & 250.

UROMYCES.
POLYGONACEAE, CARYOPHYLLACEAE, AND ZYGOPHYLLACEAE.

PLATE XIX.

(All Figures $\times 250$ unless otherwise stated.)

UROMYCES.

Fig.

158. Teleutospores, seen from above, of *Uromyces fusisporus* on *Acacia neriifolia*.
 159. Side view of same.
 160. Uredospores of same, with pronounced apiculus and equatorial band of germ pores.

UROMYCLADIUM.

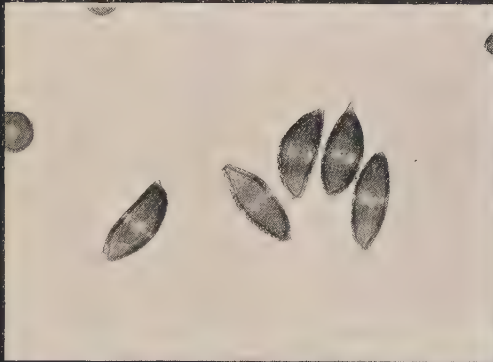
161. Teleutospores of *Uromycladium simplex* on *Acacia pycnantha*, part of the pedicel being still attached with the remains of the vesicle. (Stained).
 162. Young teleutospores of the same showing the vesicles still attached. (Stained).
 163. Portion of flake of gummy material on leaf of *Acacia pycnantha*, in which numerous teleutospores of *U. simplex* are embedded, nearly all germinating and producing sporidiola.
 164. Germinating sporidiolum of same. (Stained) $\times 500$
 165. Uredospores of same, being very similar to those of *Uromyces fusisporus*, fig. 160, though somewhat shorter and broader and possessing more germ pores.



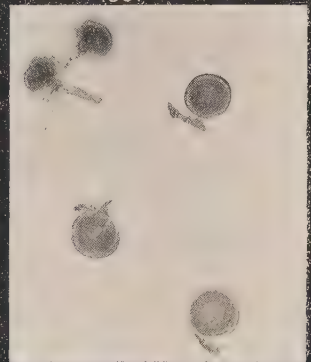
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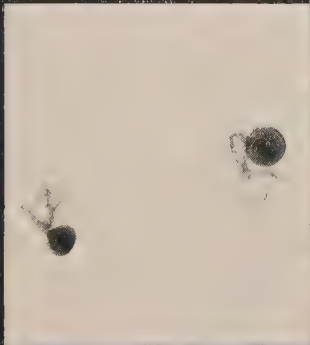
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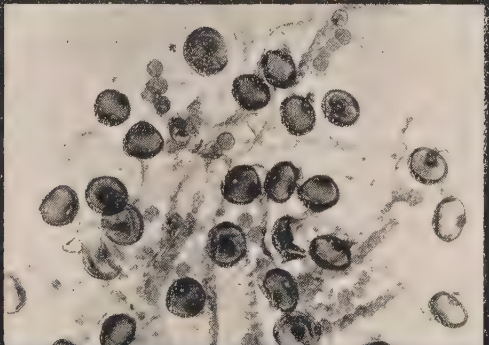
160



161



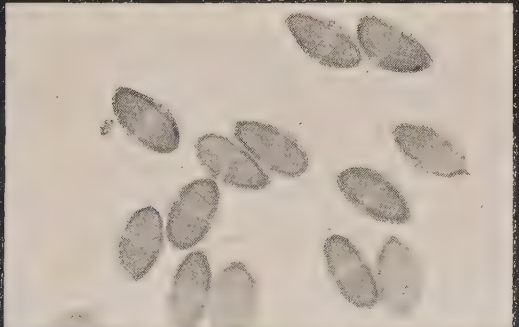
162



163



164



165

G. H. Robinson, Phot.

X 250 & 500.

UROMYCES AND UROMYCLADIUM.
LEGUMINOSAE-ACACIA.

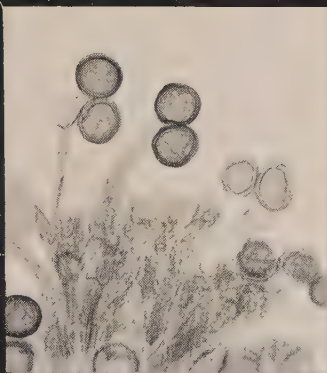
PLATE XX.

(All Figures $\times 250$.)

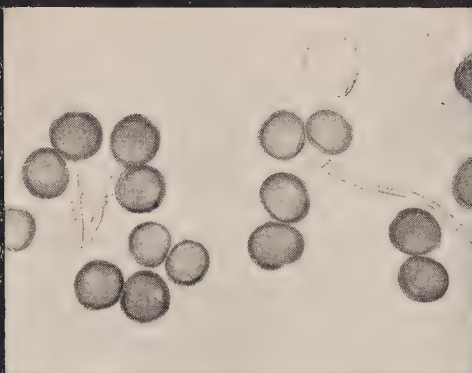
UROMYCLADIUM MARITIMUM.

Fig.

166. Section of teleutosorus of *U. maritimum* on *Acacia longifolia*, the mature teleutospores having the remains of the vesicles attached to the pedicels.
167. Group of mature teleutospores of the same.
168. Formation of teleutospore head; a young cluster, showing the two young spores at the apex, and the lateral vesicle below the septum. (Stained.)
- 169, 170. Similar heads, more advanced. (Stained.)
171. Mature teleutospore head, two teleutospores above and one vesicle below.
172. Abnormal development of head of teleutospores, the lateral vesicle being replaced by a true spore, and a septum placed in the stalk beneath it. In the normal head of two spores and a vesicle there is no septum below the vesicle.
173. Teleutospores germinating while still attached to each other; two sporidiola on one promycelium, others so far undeveloped.
174. Uredospores with prominent equatorial germ pores and serrated episporium, thickened and dentate at apex.
175. One-celled spores (mesospores ?), occasionally found intermixed with uredospores.
176. Immature two-celled colourless spore, of same character, from uredosorus. (Stained).



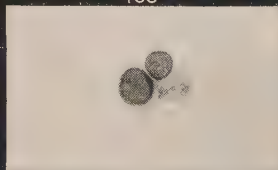
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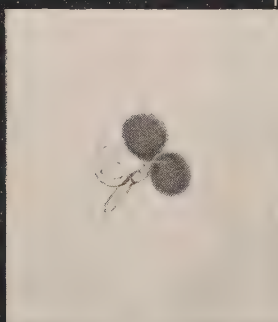
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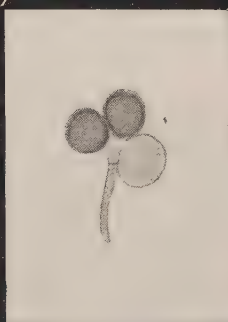
168



169



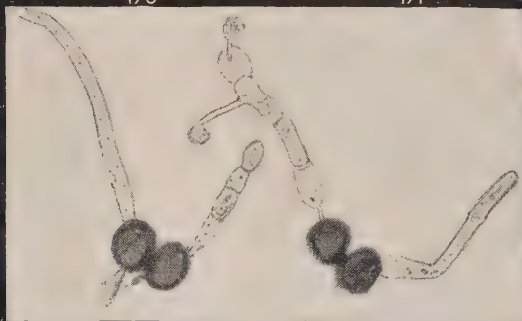
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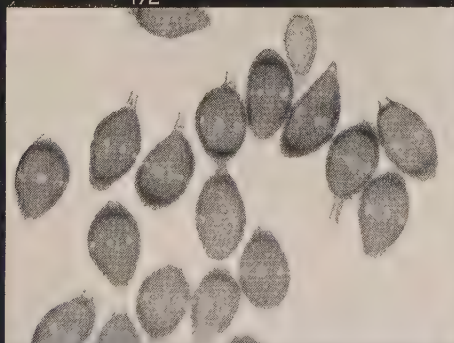
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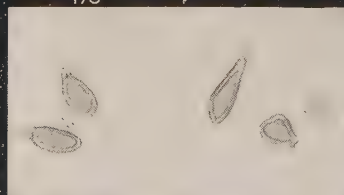
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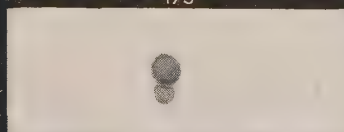
173



174



175



176

PLATE XXI.

(All Figures $\times 500$.)

UROMYCLADIUM MARITIMUM.

Fig.

177. Two young teleutospore heads, arising from common stalk, the one on the right being younger than that on the left, and both intermediate between T² and T³ in next figure. (Stained.)
178. Main stem, bearing teleutospore heads in various stages of development; T, filament with two septa, the upper two segments destined to become teleutospores, the lowermost a vesicle; T¹, similar filament, somewhat more advanced, the vesicle beginning to push out from the lowermost segment; T², similar filament still more advanced, the uppermost cell distending, in the next growth is taking place at the side, and in the lowest the vesicle has attained considerable development; T³, nearly mature head, with two dark teleutospores; U, basidium of a detached uredospore. (Stained.)
179. Abnormal teleutospore head of three teleutospores, a septum beneath the lowermost.
180. Normal teleutospore head, with two teleutospores above septum and a vesicle below, there being no septum below the vesicle.
181. Teleutospore head in which the vesicle is apparently at the apex, but this is probably due to displacement in mounting.
- 182, 183. Normal teleutospore heads.
184. Uredospores with prominent germ pores, serrated episporium thickened and dentate at apex.



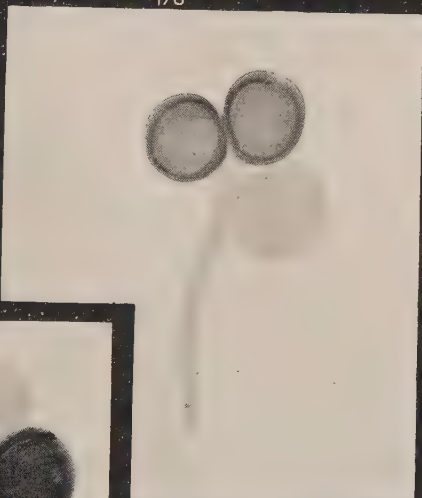
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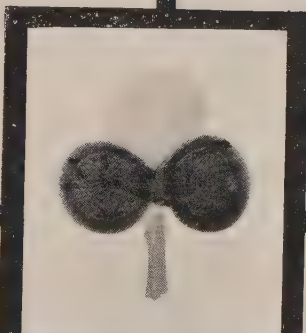
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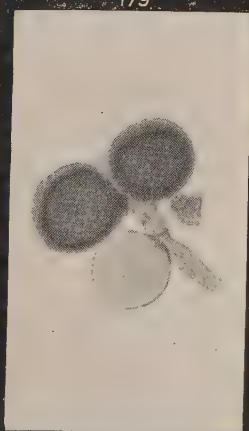
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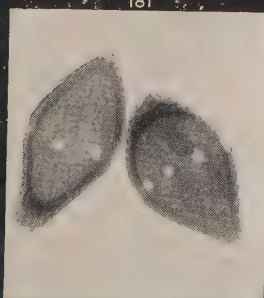
180



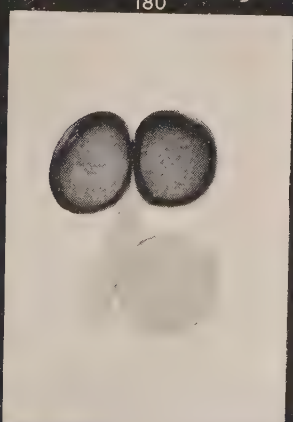
181



182



184



183

G. H. Robinson, Phot.

+ 500.

UROMYCLADIUM MARITIMUM.
LEGUMINOSAE-ACACIA LONGIFOLIA.

PLATE XXII.

(All Figures $\times 250$ unless otherwise stated.)

UROMYCLADIUM.

Fig.

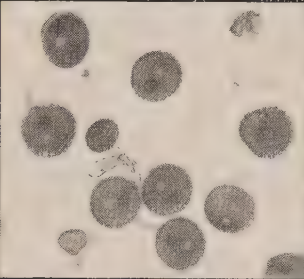
- 185, 186. Uredospores of *U. robinsoni* on *Acacia melanoxylon*. The solitary large smooth-walled spore (?) in Fig. 186 is difficult of interpretation.
187. Young and mature teleutospores of same, with and without attached vesicles. (Stained.)
188. Mature teleutospores of same, with vesicles.
189. Mature teleutospore of same germinating, the sporidiola just about to be formed. (Stained.)
- 190, 191, 192. Successive stages in the development of a teleutospore head of *U. tepperianum* on *Acacia salicina*, the striated episporium being clearly shown in 192. (Stained.) $\times 500$
193. Single teleutospore of same, seen from above, and showing striated markings $\times 500$
194. Mature teleutospore head of same. (The markings are indistinct on account of poor condition of material) $\times 500$
195. Detached teleutospores of same.



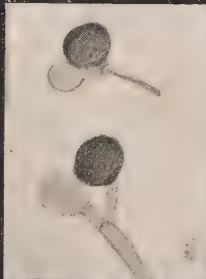
185



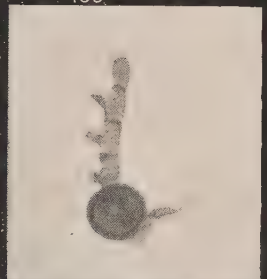
186



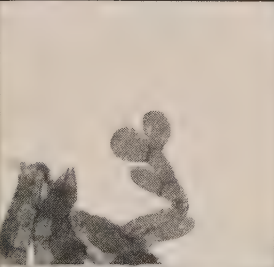
187



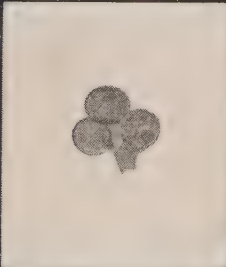
188



189



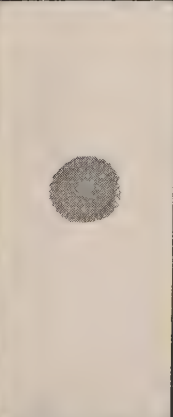
190



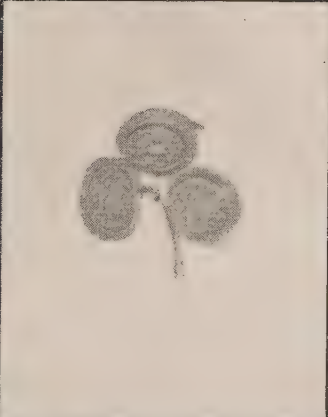
191



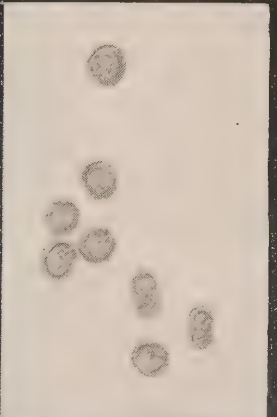
192



193



194



195

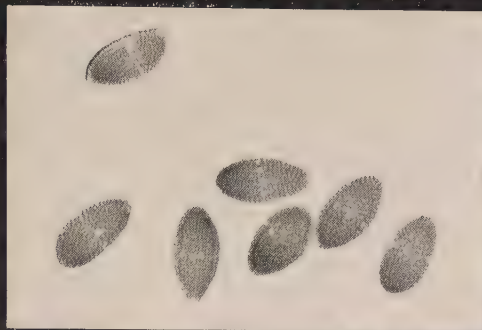
PLATE XXIII.

(All Figures $\times 250$ unless otherwise stated.)

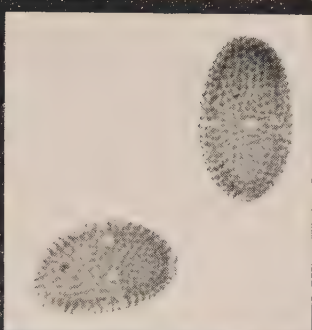
UROMYCLADIUM.

Fig.

196. Uredospores of *U. notabile* on *Acacia notabilis*. Original type material of *Uredo notabilis* Ludw. (Somewhat swollen by lengthened treatment with caustic potash.)
197. Uredospores of the same, showing the net-like surface markings. ... $\times 500$
198. Compound stem, with basidia and uredospores of the same.
199. Compound structure from uredosorus of same, being probably commencement of teleutospore formation ... $\times 500$
200. Uredospores of *U. notabile* on *Acacia dealbata*.
- 201, 202. Uredospores of the same, showing the net-like surface markings... $\times 500$
203. Portion of spermogonium of the same, with basidia bearing spermatia in chains. (Stained) ... $\times 500$
204. Cluster of three immature spores of the same, attached to their stalk. (Stained.)
205. Mass of mature teleutospores of the same, separated from each other, from *Acacia decurrens*.
206. Mass of scarcely mature teleutospores, separated from each other, of *U. teparianum*, on *Acacia melanoxylon*, from Cheltenham, showing striated markings on the surface. These are considerably smaller than the average.



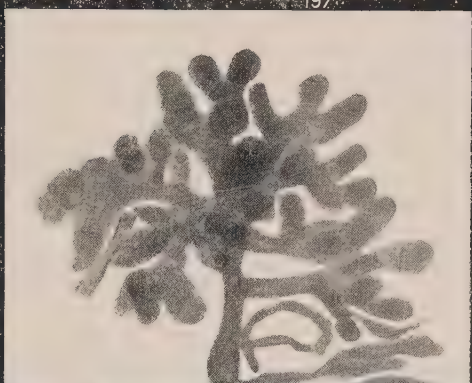
196



197



198



199



200



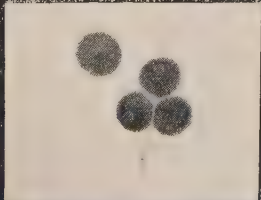
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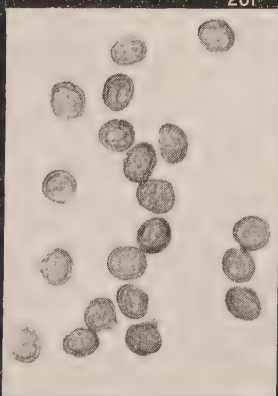
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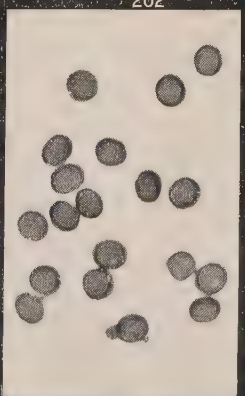
203



204



205



206

G. H. Robinson, Phot.

× 250 & 500.

UROMYCLADIUM.
LEGUMINOSAE-ACACIA.

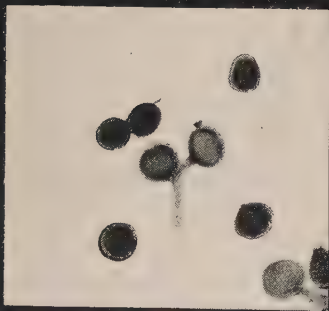
PLATE XXIV.

(All Figures $\times 250$ unless otherwise stated.)

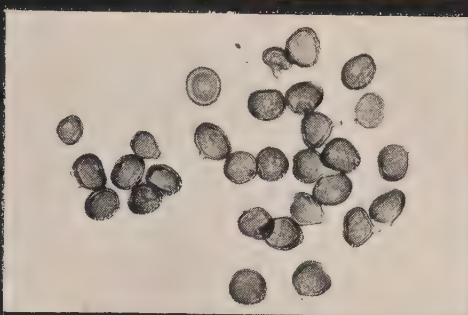
UFOMYCLADIUM.

Fig.

207. Teleutospores of *U. bisporum*, on *Acacia dealbata*, one cluster of two showing the common stalk.
208. Teleutospores of the same.
209. Uredospores of *U. alpinum*, on *Acacia dealbata*.
- 210, 211. Teleutospores of the same.
212. Five uredospores of *U. alpinum* on *Acacia dallachiana*, mixed with teleutospores and one mesospore (M).
- 213, 214. Successive stages in the development of teleutospore clusters of the same. (Stained.)
215. Group of teleutospores of the same.
216. Section of leaf of *Acacia longifolia* attacked by *U. maritimum*, the uredosori being at the margin of the inflated tubercle, and the spermogonia in the centre $\times 30$
217. Uredospore of *U. maritimum* attacked by some Hyphomycete, which has gained access to the interior of the spore and grown within it preparatory to forming the long septate threads which have pierced the wall near the germ pores.



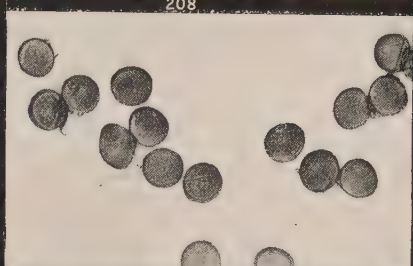
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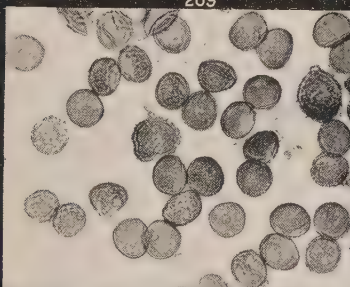
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209



210



211



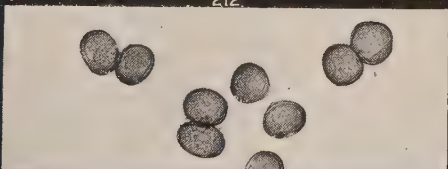
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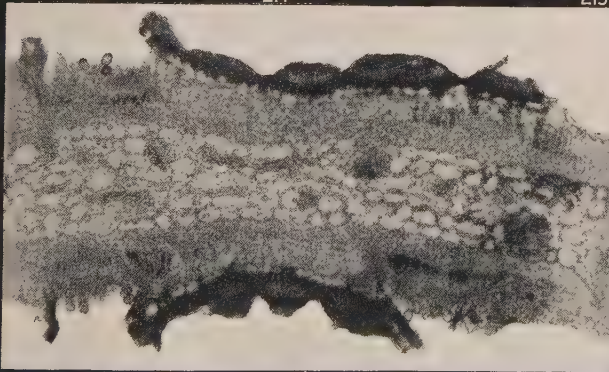
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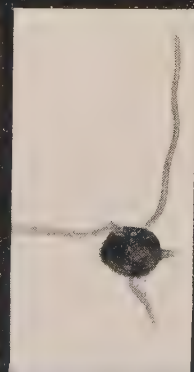
214



215



216



217

G. H. Robinson, Phot.

× 80 & 250.

UROMYCLADIUM.
LEGUMINOSAE-ACACIA.

PLATE XXV.

(All Figures $\times 250$ unless otherwise stated.)

UROMYCES PHYLLODIORUM.

Fig.

218. Two uredospores of *U. phyllodiorum* (B. and Br.) McAlp., on *Acacia* sp. from Queensland. (Type material of *Melampsora phyllodiorum* B. and Br., from Herbarium of F. M. Bailey, Government Botanist, Queensland.)

219. One of the very sparse digitate teleutospores present in the same material.

220. Uredospore from the same material ... $\times 500$
(All the above from old and much faded material.)

221, 222. Uredospores of *U. phyllodiorum*, on *Acacia* sp. from Queensland. (Type material of *Uromyces phyllodiae* Cooke and Mass., these uredospores being described as teleutospores. From Herbarium of F. M. Bailey.)

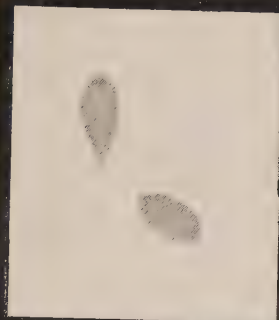
223, 224. Two of the few digitate teleutospores present in the same material.
(Material of above old and much faded.)

225. Uredospores of *U. phyllodiorum* on *Acacia dallachiana*, from Bright, Victoria.

226. Two of the same, more highly magnified, to show surface markings ... $\times 500$

227, 228. Teleutospores from the same material, some beginning to germinate.
(Stained.)

NOTE.—The markings of the uredospores are arranged in distinct lines, and are not net-like as in *Uromycladium notabile*.



218



219



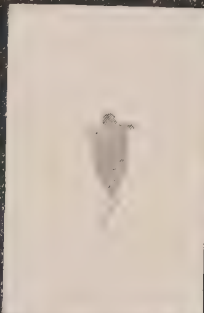
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221



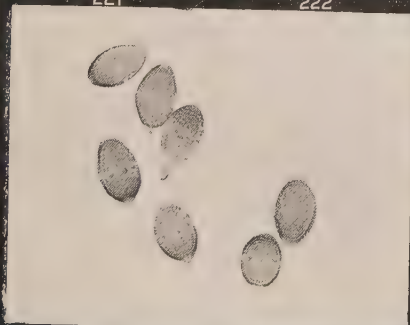
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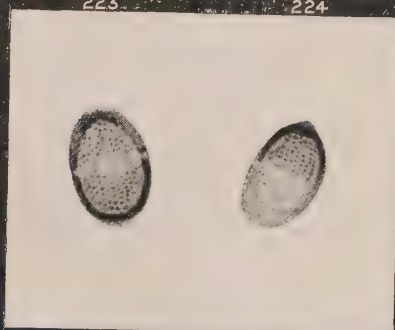
223



224



225



226



227



228

G. H. Robinson, Phot.

× 250 & 500.

UROMYCES PHYLLODIORUM.
LEGUMINOSAE-ACACIA.

PLATE XXVI.

(All Figures $\times 250$ unless otherwise stated.)

PHRAGMIDIUM, MELAMPSORA.

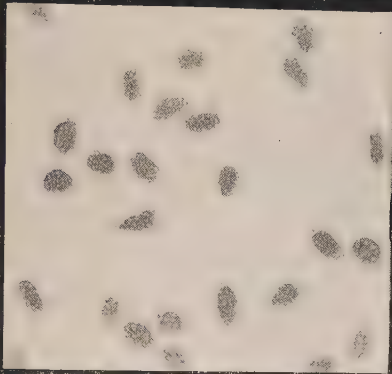
Fig.

229. Aecidiospores of *Phr. subcorticium* on *Rosa rubiginosa*.

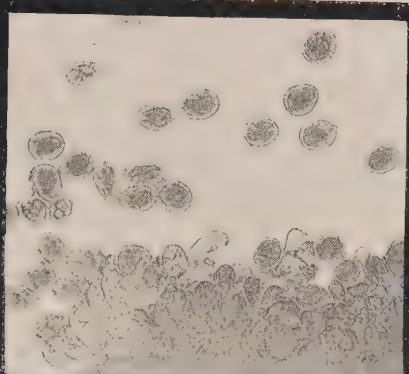
230. Uredospores of same.

231, 232. Teleutospores of same.

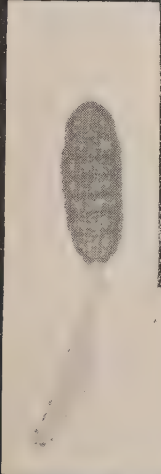
233. Twig of *Rosa rubiginosa*, the uppermost shoot of which is swollen and distorted by the aecidia of *Phr. subcorticium*. nat. size234, 235. Teleutospores and uredospore of *P. barnardi* on *Rubus parvifolius*, two germ pores being often seen on one face of each cell.236. Teleutospores, closely attached to each other, of *Melampsora lini* on *Linum usitatissimum*.



229



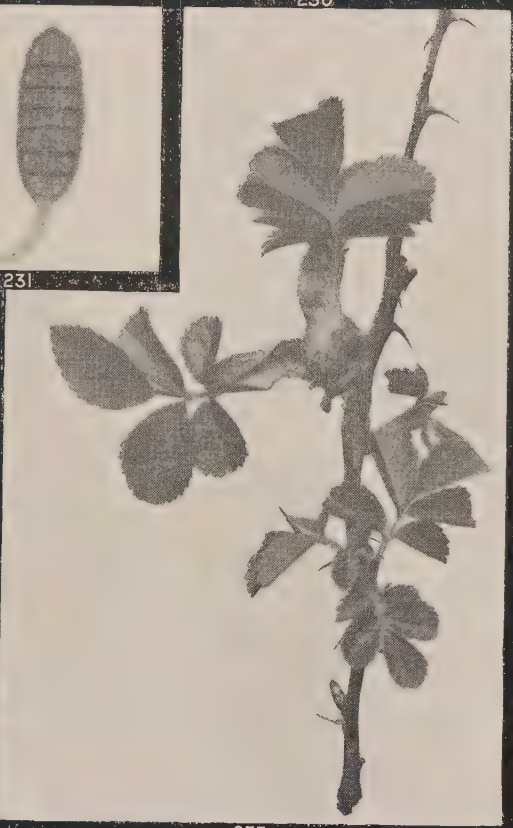
230



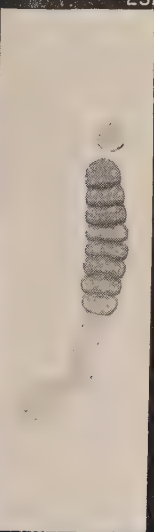
232



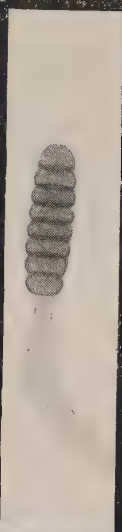
231



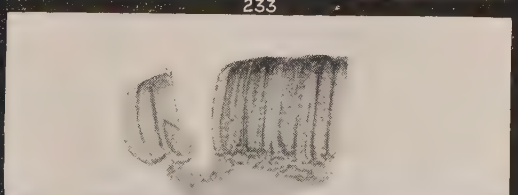
233



234



235



236

G. H. Robinson, Phot.

Nat. size & X 250.

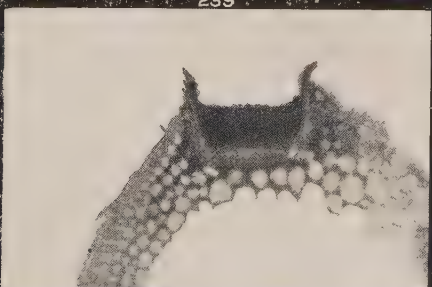
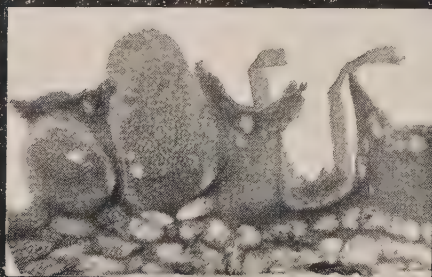
PHRAGMIDIUM AND MELAMPSORA.
ROSACEAE AND LINACEAE.

PLATE XXVII.

AECIDIUM.

Fig.

237. Young seedling of *Platylobium formosum*, with *Aecidium platylobii* on leaves
and leaf stalks nat. size
238. Fruiting branch of the same, with aecidial cups on the pods ... nat. size
239. Section through cups of *Aecidium eburneum* on pod of *Bossiaea hetero-*
phylla × 50
240. Section of aecidial cup of *Puccinia erechitidis* on *Erechtites quadridentata* × 50



G. H. Robinson, Phot.

Nat. size & $\times 50$.

AECIDIA.
LEGUMINOSAE AND COMPOSITAE.

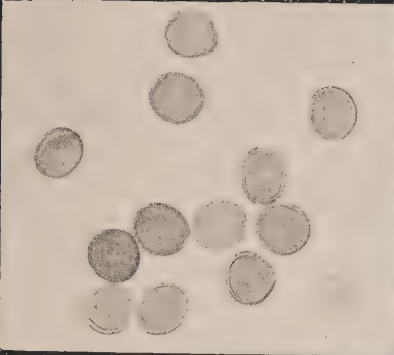
PLATE XXVIII.

(All Figures $\times 250$).

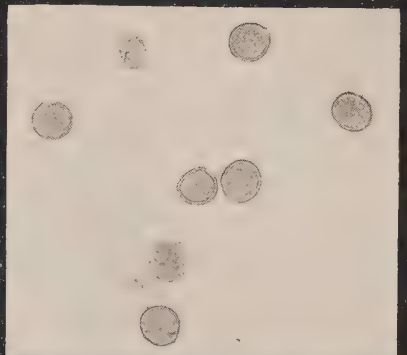
UREDINA.

Fig.

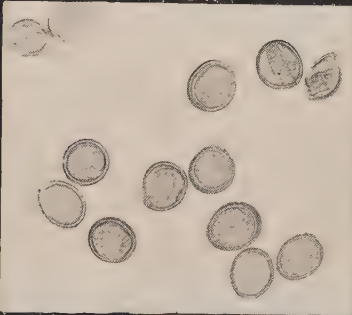
241. Spore of *Uredo scirpi-nodosi* or *Scirpus nodosus*.
242. Uredospores of *Puccinia stylidii* on *Stylidium graminifolium*.
243. *U. bidentis* on *Bidens pilosa* from Queensland.
244. *U. bidentis* on *Bidens pilosa* from Brazil. (Sydow, Uredineen, 1647.)
245. *U. spyridii* on *Spyridium parvifolium*.
246. *U. bossiaee* on *Bossiaea prostrata*.
247. *U. pallidula* on *Cassia* sp.
248. Uredospores of *Uromyces scleranthi* on *Scleranthus diander*.
249. Uredospores of *Puccinia oleariae* on *Olearia argophylla*, epispore finely striate.



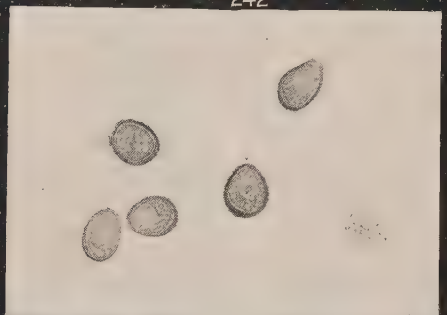
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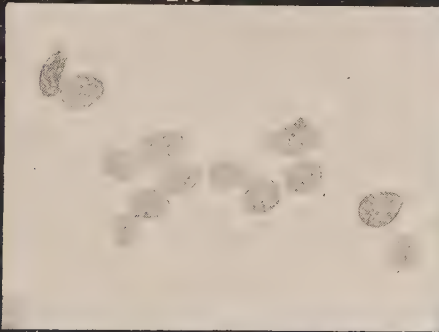
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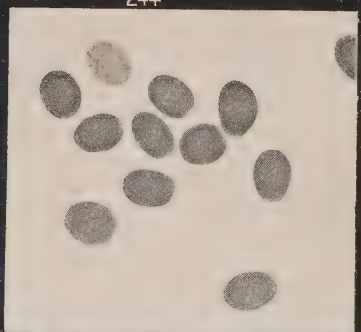
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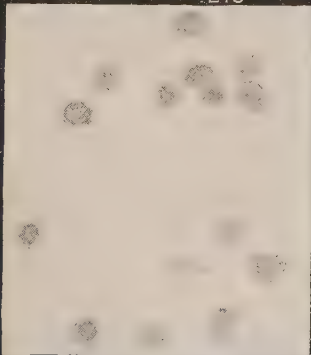
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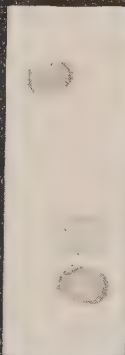
245



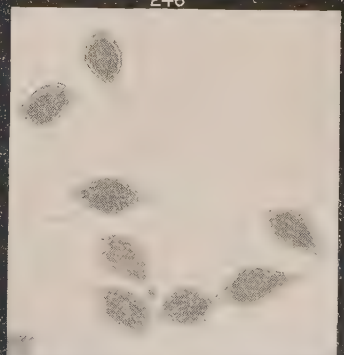
246



247



248



249

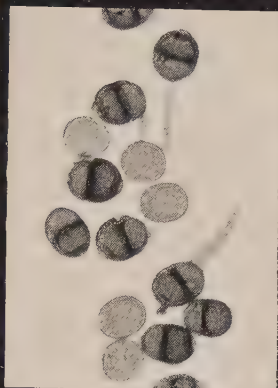
PLATE XXIX.

(All Figures $\times 250\times$)

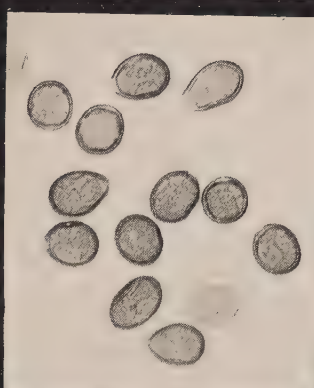
ADDENDA TO PUCCINIA.

Fig.

250. Uredospores and teleutospores of *Puccinia menthae* on *Mentha pulegium*.
251. Uredospores of *P. chrysanthemi* on *Chrysanthemum indicum*, from New South Wales.
252. Isolated teleutospore found associated with the same.
253. Uredospores and teleutospores of *P. chrysanthemi* on *Chrysanthemum* cult., Japan. (Herbarium A. Ideta.)
254. Abnormal teleutospore associated with uredospores and teleutospores of same.
255. Mesospore from same.
256. Group of teleutospores and mesospores of *P. podolepidis* on *Podolepis longipedata*.
257. Teleutospore from same, with hyaline germ pore at each side of apex of upper cell.
258. Teleutospores of *P. operculariae* on *Opercularia varia*.



250



251



252



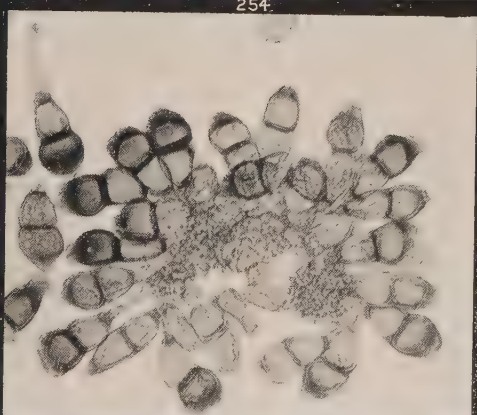
253



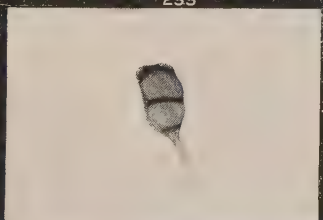
254



255



256



257



258

G. H. Robinson, Phot.

× 250.

PUCCINIA.
LABIATAE, COMPOSITAE AND RUBIACEAE.



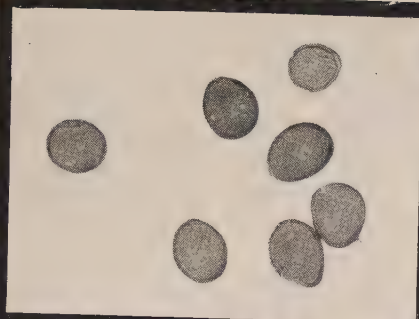
PLATE XXX.

(All Figures $\times 250$.)

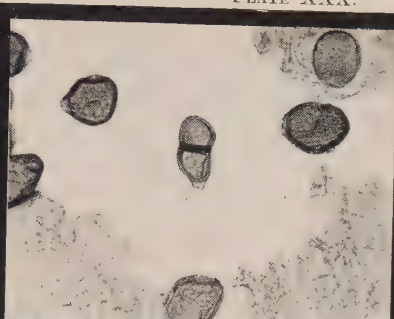
ADDENDA TO PUCCINIA AND UREDO.

Fig.

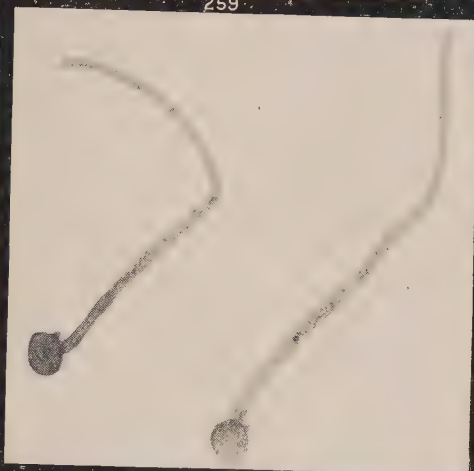
259. Uredospores of *Puccinia cacao* on *Rottboellia compressa*.
260. Uredospores and one teleutospore of same.
261. Uredospores of *P. lolii avenae* on *Avena sativa*, germinating in water after 24 hours. (Stained.)
262. Uredospores of *P. subnitens* on *Distichlis maritima*.
- 263, 264. Teleutospores from same.
265. Teleutospores of *P. hibbertiae* on *Hibbertia sericea*.
266. Teleutospores of *P. cruciferae* on an undetermined Crucifer. From type material referred to *Aecidium barbareae* DC., at Kew.
267. *Uredo rhagodiae* on *Rhagodia billardieri*.



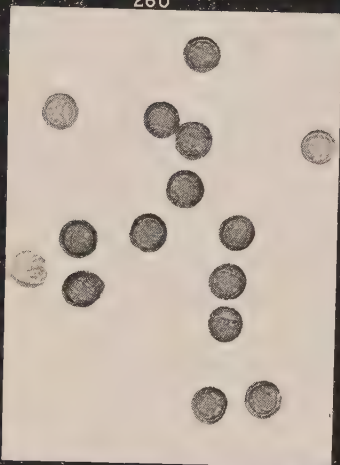
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260



261



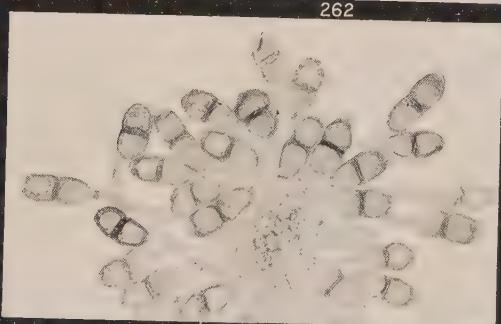
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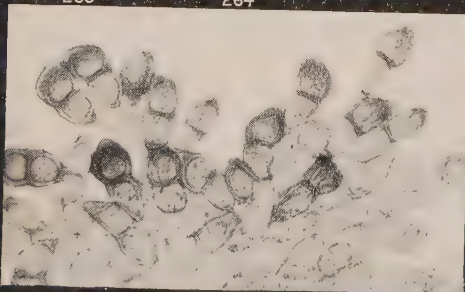
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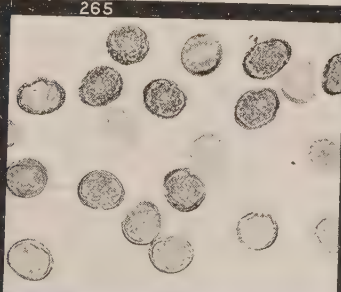
264



265



266



267

PLATE XXXI.

(All Figures $\times 250$ unless otherwise stated.)

ADDENDA TO PUCCINIA AND PHRAGMIDIUM.

Fig.

268. Leaf of *Loranthus celastroides*, showing uredosori and teleutosori of *Puccinia loranthicola* nat. size

269. Teleutospores from same.

270. Uredospores from same.

271. Leaf of *Loranthus celastroides*, with aecidia of same nat. size

272. Teleutospores of *Phragmidium longissimum*.

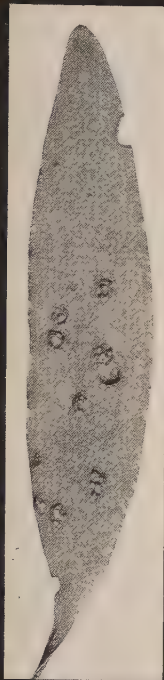
a. Four and five celled spores, before germination.

b. Spores commencing to germinate, with one germ tube divided by a septum.

c. Spore cell, giving rise to four-celled promycelium, with loose sporidiola around it.

The material was fourteen years old, and although there were plenty of sporidiola, none were found attached to the promycelia.

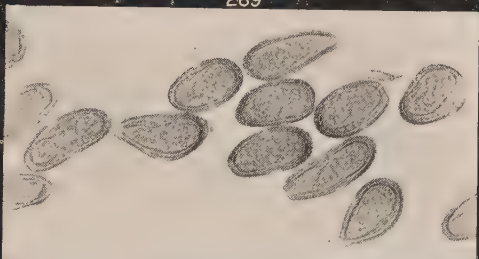
NOTE.—Figs. 272, *a*, *b*, *c*, from drawings.



268



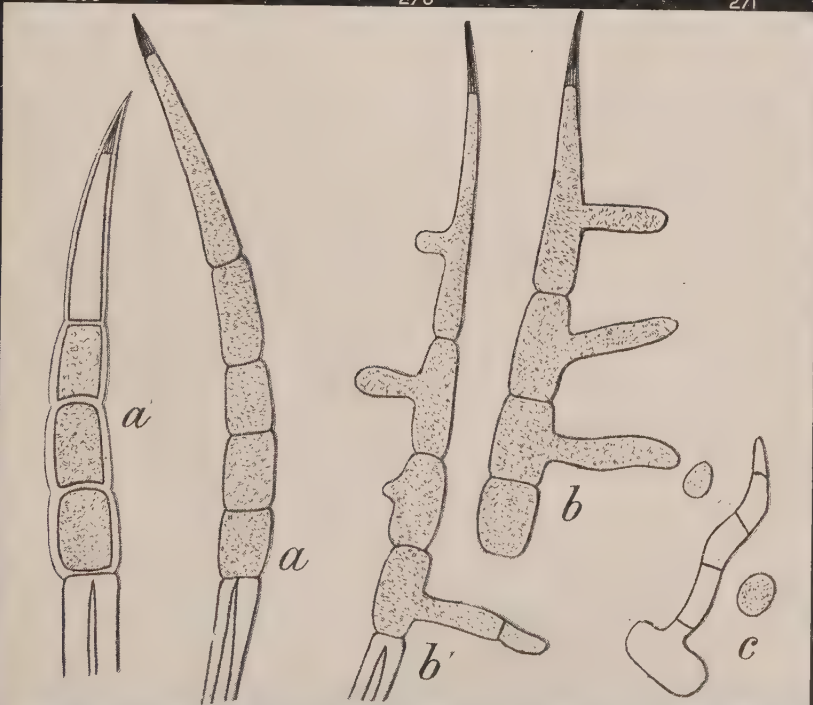
269



270



271



272

G. H. Robinson, Phot.

× 250 & 500.

Puccinia and Phragmidium.
Loranthaceae and Rosaceae.

PLATE XXXII.

UROMYCLADIUM.

Fig.

273. Leaves of *Acacia longifolia*, with the tuberculate spermogonial sori of *Uromycladium maritimum* nat. size
274. Leaves of *Acacia melanoxylon*, the upper with tuberculate spermogonial sori, and the lower with minute pulverulent sori, both of *U. robinsoni*. ... nat. size
275. Leaf of *Acacia pycnantha*, with the minute powdery sori of *U. simplex*. nat. size



G. H. Robinson, Phot.

Nat. size.

UROMYCLADIUM.

U. MARITIMUM, U. ROBINSONI, AND U. SIMPLEX ON ACACIA.

PLATE XXXIII.

UROMYCLADIUM BISPORUM.

Fig.

276. Sori of *U. bisporum* on stems and leaf stalks of *Acacia dealbata* ... nat. size.

277. Sori on fruits nat. size



G. H. Robinson, Phot.

Nat. size.

UROMYCLADIUM.
LEGUMINOSAE—ACACIA DEALBATA.

PLATE XXXIV.

UROMYCLADIUM TEPPERIANUM.

Fig.

278. Branch of *Acacia armata* showing the powdery growth caused by the growth of
U. tepperianum nat. size



G. H. Robinson, Phot.

Nat. size.

UROMYCLADIUM.
LEGUMINOSAE—ACACIA ARMATA.

PLATE XXXV.

UROMYCLADIUM TEPPERIANUM.

Fig.

- | | | |
|------|--|---------------|
| 279. | Galls attached to branches of <i>Acacia pycnantha</i> , caused by <i>U. tep-</i> | |
| | <i>perianum</i> | ... nat. size |
| 280. | Galls detached | ... nat. size |



G. H. Rotinson, Phot.

Nat. size.

UROMYCLADIUM.
U. TEPPERIANUM ON ACACIA PYCNANTHA.

PLATE XXXVI.

UROMYCLADIUM NOTABILE.

Fig.

281. Numerous young galls on *Acacia dealbata*, bearing the uredospores of *U. notabile* nat. size

(Being on the young growth of the current season, the galls are necessarily comparatively small, though many of several years' growth bearing teleutospores have been found as large as potatoes, and weighing nearly 1 lb. each.)



G. H. Robinson, Phot.

Nat. size.

UROMYCLADIUM.
U. NOTABILE ON ACACIA DEALBATA.

PLATE XXXVII.

CRONARTIUM JACKSONIAE.

Fig.

- | | | | | |
|------|---|-----|-----|-----------|
| 282. | <i>C. jacksoniae</i> deforming shoot of <i>Platylobium formosum</i> | ... | ... | nat. size |
| 283. | Witches' brooms due to <i>C. jacksoniae</i> on branches of <i>Aotus villosa</i> | ... | | nat. size |
| 284. | Normal healthy shoot of <i>Aotus villosa</i> | .. | ... | nat. size |



G. H. Robinson, Phot.

Nat. size.

CRONARTIUM.
C. JACKSONIAE ON PLATYLOBIUM AND AOTUS.

PLATE XXXVIII.

CRONARTIUM JACKSONIAE.

Fig.

285. Witches' broom, due to *C. jacksoniae* on *Gompholobium latifolium* ... nat. size
286. Normal healthy shoot of *Gompholobium latifolium* ... nat. size



G. H. Robinson, Phot.

Nat. size.

CRONARTIUM.
C. JACKSONIAE ON GOMPHOLOBIUM LATIFOLIUM.

PLATE XXXIX.

(All aecidia $\times 50$, and aecidiospores $\times 300$.)

AECIDIUM:

Fig.

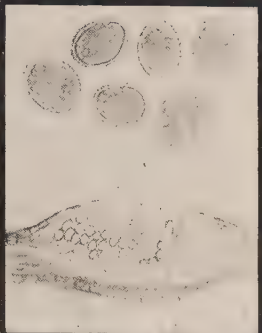
287. *A. veronicae* on *Veronica* sp.288. *A. plantaginis-variae* on *Plantago varia*.289. *A. lobeliae* Thuem., on *Lobelia pratensis*, described in connexion with *Puccinia aucta*. The free margin ruptures irregularly, and it is sometimes difficult to detect a peridial wall, so that it partakes of the nature of a *Caeoma*.290. *A. cymbonoti* on *Cymbonotus lawsonianus*.291. *A. monocystis* on *Abrotanella forsterioides*.292. *A. vittadiniae* on *Vittadinia australis*.293. *A. soleniforme* on *Goodia lotifolia*.294. *A. deeringiae* on *Deeringia celosioides*.295. *A. calthae* on *Caltha introloba*.296. *A. ranunculacearum* on *Ranunculus rivularis*.297. Aecidium of *Uromyces politus* on leaves of *Muehlenbeckia cunninghami*—*a.* nat. size, *b.* aecidial tubes $\times 5$.298. Aecidiospores of same ($\times 300$) and pseudoperidial cells ($\times 150$).



287



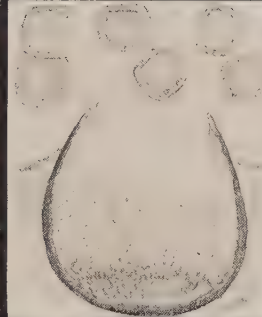
288



289



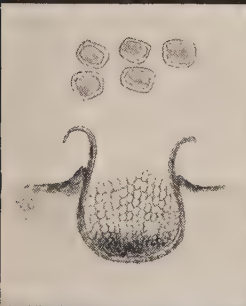
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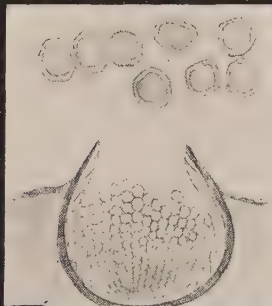
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292



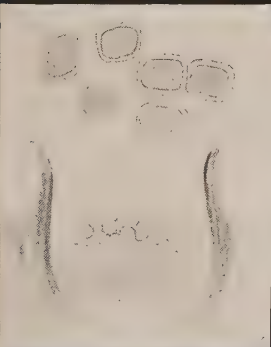
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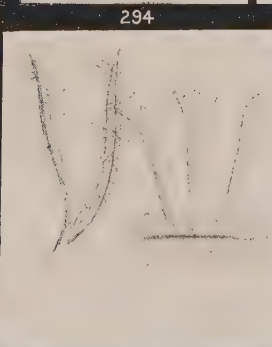
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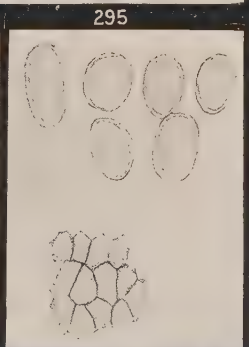
295



296



297



298

C. C. Brittlebank, Del.

x 5, 50, 150 & 300.

AECIDIUM.

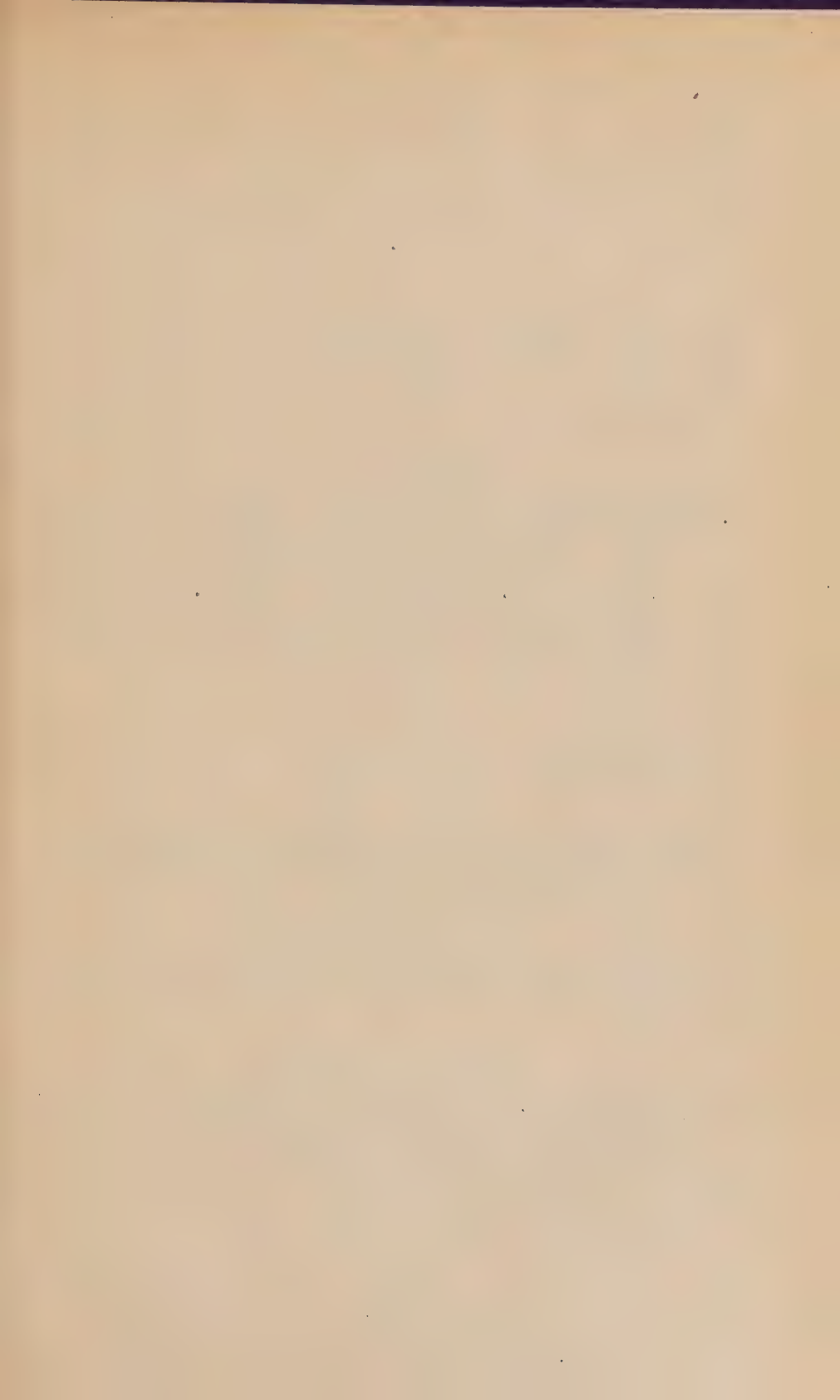


PLATE XL.

(All Figures $\times 500$.)

NORMAL AND ABNORMAL SPORES OF PUCCINIA AND UROMYCES.

PUCCINIA DICHONDRAE.

Fig.

299. The teleutospores exhibit a great variety of shape and size, and range from one to four celled forms. In the two-celled forms the septum may either be transverse or longitudinal, and in the three-celled forms the septa may either be transverse or oblique, and the upper or lower cell may be divided longitudinally. The four-celled forms may, in addition, become somewhat spherical, and be divided longitudinally and obliquely, so as to resemble a *Sphaerophragmium*. The variation even in the same sorus is sometimes greater than it is between some different species.

PUCCINIA LUDWIGII.

300. Teleutospores may be divided generally as in the above, although the four-celled forms are not quite so frequent.

PUCCINIA GRAMINIS.

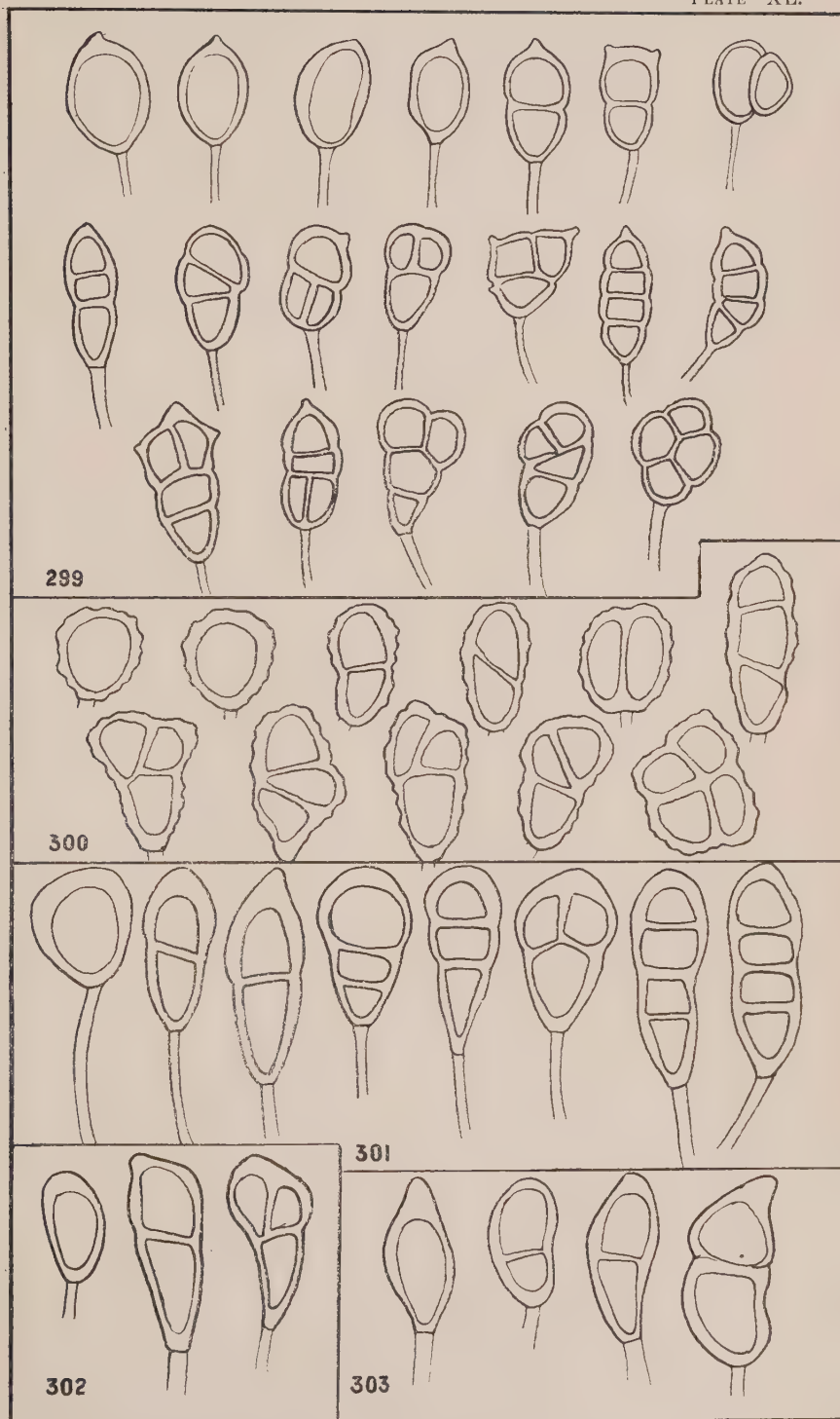
301. Teleutospores are also one to four celled, but the septa are generally transverse, while the upper cell may occasionally be longitudinally divided.

PUCCINIA TRITICINA.

302. The teleutospores do not show such a wide variation as in *P. graminis*, but they may be from one to three celled, and the upper cell may be longitudinally divided.

UROMYCES ORCHIDEARUM.

303. This species shows very well the transition from the unicellular (*Uromyces*) to the bicellular (*Puccinia*) teleutospores. Some of the two-celled spores are equally divided by the transverse septum and constricted, so that they depart entirely from the *Uromyces* type.



C. C. Brittlebank, Del.

× 500.

PUCCINIA AND UROMYCES.
NORMAL AND ABNORMAL TELEUTOSPORES.

PLATE XLI.

UROMYCLADIUM TEPPERIANUM.

Fig.

304. Large gall on *Acacia implexa*, weight 3 lbs. $\times \frac{1}{2}$



G. H. Robinson, Phot.

UROMYCLADIUM.
LEGUMINOSAE—ACACIA IMPLEXA.

X $\frac{1}{2}$

PLATE XLII.

UROMYCLADIUM.

Fig.

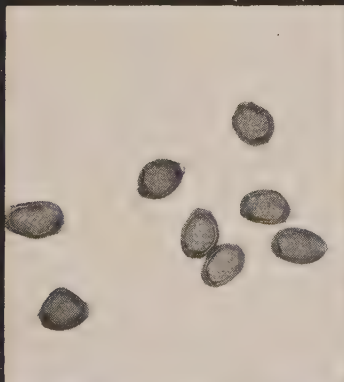
305. Witches' broom on *Acacia implexa*, due to *Uromycladium tepperianum* ... $\times \frac{1}{4}$

UROMYCES.

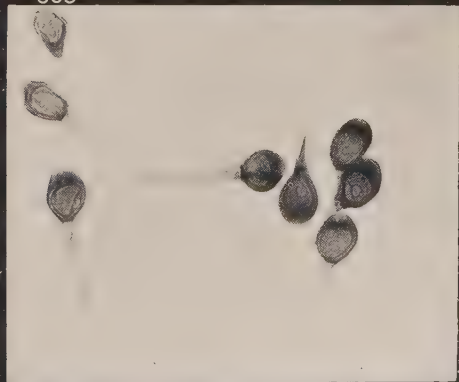
306. Teleutospores of *Uromyces appendiculatus* on *Vigna catjang* or Cow-pea, from
 Richmond, New South Wales $\times 250$
307. Teleutospores of *Uromyces fabae* on *Lathyrus venosus*. (Sydow, Uredineen,
 1353) $\times 250$



305



306



307

G. H. Robinson, Phot.

$\times \frac{1}{4}$ & 250.

UROMYCLADIUM, UROMYCES.
LEGUMINOSAE.

PLATE XLIII.

(All Figures $\times 250$.)

PUCCINIA.

Fig.

308. Teleutospores of *P. vittadiniac*, mostly of a short broad type, on *Vittadinia australis*.
309. Teleutospores and mesospores of the same.
310. Teleutospores and mesospores of *P. calotidis* on *Calotis* sp.
311. Uredospore of *P. graminis* on *Avena fatua*, germinating in water, showing branching growth at the end of twenty-four hours. (Stained with Congo red.)
312. Mesospore of *P. calendulae* on *Calendula officinalis*, germinating in water after three days, two sporidiola produced, both of which have already germinated. (Stained with Bismarck brown.)

UROMYCLADIUM.

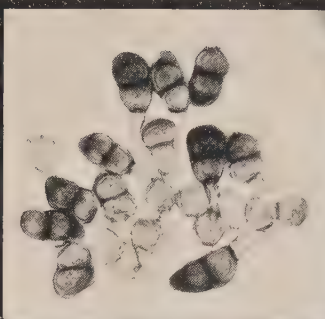
313. Teleutospore of *U. maritimum* on *Acacia longifolia*, germinating after twenty-four hours in water, and producing four sporidiola from the lengthy promycelium. (Stained with Congo red.) (In some cases the promycelium may be quite three times the length of that shown when germination takes place in water.)
314. Sporidiola of the same germinating in water three hours after formation. (Stained with Congo red.)
315. Uredospores of the same germinating after three days in water. The germ tubes are very broad, with almost colourless contents, and extremely thin wall. At first they are generally much contorted, and sometimes bifurcate at the apex. (Stained with Congo red.)

UROMYCES.

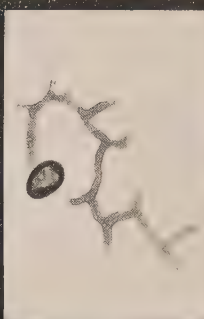
316. Aecidiospore of *U. betae* on *Beta vulgaris*, germinating in water after twenty-four hours, the contents being collected towards the end of the tube where branching is commencing. (Stained with Congo red.)
317. Teleutospores of *U. politus*, one being two-celled, on *Muehlenbeckia cunninghami*.
318. Uredospores with two bands of germ pores, and teleutospores of *U. bicinctus* on *Acacia fasciculifera*.
319. Uredospores and teleutospores of *U. polynemi* on *Polynemum pentandrum*.



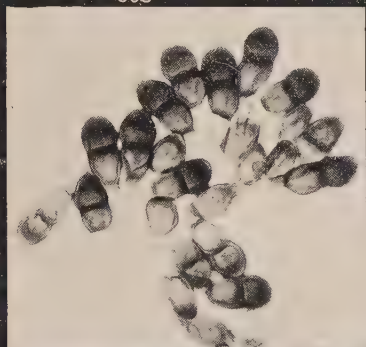
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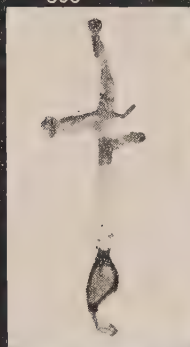
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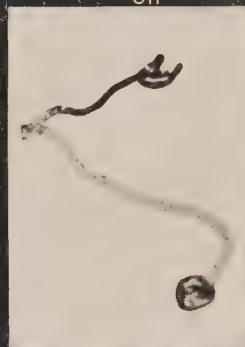
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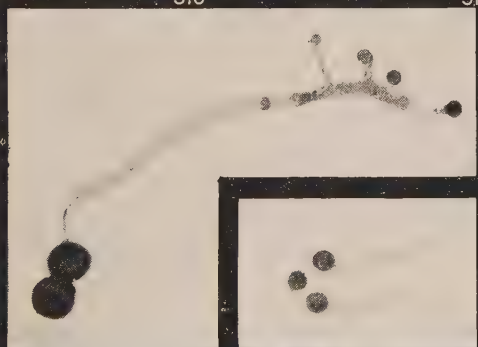
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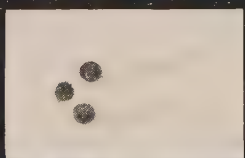
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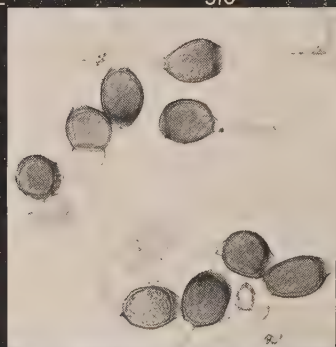
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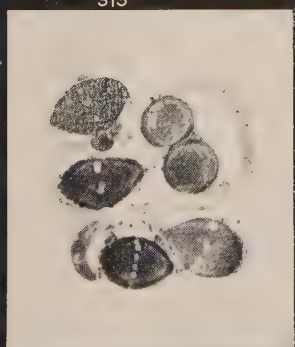
313



314



317



315



318



319

PLATE XLIV.

RUST-RESISTING AND RUST-LIABLE WHEATS.

Fig.

320. Rerraf, a variety of wheat generally found to be rust-resisting, and the straw is shown to be perfectly clean.
321. Queen's Jubilee, a rust-labile variety, grown alongside of the other, and badly attacked by *Puccinia graminis*.



3-colour process.

Fig. 320.

RERRAF.

Straw perfectly clean.

R. S. BRAIN, Govt. Printer.

Fig. 321.

QUEEN'S JUBILEE.

Straw badly rusted.

HOST INDEX.

- Abrotanella forsterioides** Hook. f.
Acidium monocystis, Berk.
- Abutilon avicennae** Gaertn.
Puccinia heterospora, Berk. and Curt.
- Abutilon crispum** Sweet.
Puccinia heterospora, Berk. and Curt.
- Acacia L.**
Uromyces fusisporus, Cke. and Mass.
Uromyces phyllodiorum (B. and Br.) McAlp.
- Acacia armata** R. Br.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia buxifolia** A. Cunn.
Uromycladium alpinum, McAlp.
- Acacia binervata** DC.
Uromycladium notabile (Ludw.) McAlp.
- Acacia dallachiana** F.v.M.
Uromyces phyllodiorum (Berk. and Br.) McAlp.
Uromycladium alpinum, McAlp.
- Acacia dealbata** Link.
Uromyces phyllodiorum (B. and Br.) McAlp.
Uromycladium alpinum, McAlp.
U. bisporum, McAlp.
U. notabile (Ludw.) McAlp.
- Acacia decurrens** Willd.
Uromycladium notabile (Ludw.) McAlp.
- Acacia diffusa** Lindl.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia elata** A. Cunn.
Uromycladium notabile (Ludw.) McAlp.
- Acacia erioclada** Benth.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia fasciculifera** F. v. M.
Uromyces bicinctus, McAlp.
- Acacia glaucoptera** Benth.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia hakeoides** A. Cunn.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia implexa** Benth.
Uromycladium tepperianum (Sacc.) McAlp.
U. alpinum, McAlp.
- Acacia juniperina** Willd.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia linifolia** Willd.
Uromycladium alpinum, McAlp.
- Acacia longifolia** Willd.
Uromycladium maritimum, McAlp.
U. tepperianum (Sacc.) McAlp.
- Acacia melanoxylon** R. Br.
Uromycladium robinsoni, McAlp.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia microbotrya** Benth.
Uromyces phyllodiorum (B. and Br.) McAlp.
- Acacia myrtifolia** Willd.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia neriifolia** A. Cunn.
Uromyces fusisporus, Cke. and Mass.
U. phyllodiorum (B. and Br.) McAlp.
- Acacia notabilis** F.v.M.
Uromyces phyllodiorum (B. and Br.) McAlp.
Uromycladium notabile (Ludw.) McAlp.
- Acacia penninervis** Sieber.
Uromyces phyllodiorum (B. and Br.) McAlp.
- Acacia pruinosa** A. Cunn.
Uromyces phyllodiorum (B. and Br.) McAlp.
Uromycladium notabile (Ludw.) McAlp.
- Acacia pycnantha** Benth.
Uromycladium simplex, McAlp.
U. tepperianum (Sacc.) McAlp.
- Acacia retinodes** Schlecht. = *Acacia neriifolia*, A. Cunn.
- Acacia rigens** A. Cunn.
Uromycladium tepperianum (Sacc.) McAlp.
- Acacia salicina** Lindl.
Uromyces fusisporus, Cke. and Mass.
Uromycladium tepperianum (Sacc.) McAlp.

- Acacia siculiformis** A. Cunn.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acacia spinescens** Benth.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acacia stricta** Willd.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acacia verniciflua** A. Cunn.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acacia verticillata** Willd.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acacia vomeriformis** A. Cunn.
Uromycladium tepperianum (Sacc.)
McAlp.
- Acaena ovina** A. Cunn.
Phragmidium potentillae (Pers.)
Karst
- Acaena sanguisorbae** Vahl.
Phragmidium potentillae (Pers.)
Karst.
- Agropyron divergens** Nees.
Puccinia graminis, Pers.
- Agropyron scabrum** Beauv.
Puccinia agropyri, Ell. and Ev.
P. graminis, Pers.
- Agrostis solandri** F.v.M. = Deyeuxia
forsteri, Kunth.
- Alopecurus geniculatus** L.
Puccinia graminis, Pers.
P. perplexans, Plow.
- Althaea rosea** Cav.
Puccinia malvacearum, Mont.
- Alyxia buxifolia** R. Br.
Puccinia alyxiae, Cke. and Mass.
- Amphibromus neesii** Steud.
Puccinia graminis, Pers.
- Anthoxanthum odoratum** L.
Puccinia anthoxanthi, Fekl.
- Aotus villosa** Sm.
Cronartium jacksoniae, P. Henn.
- Apium graveolens** L.
Puccinia thuemeni, McAlp.
- Apium prostratum** Labill.
Puccinia thuemeni, McAlp.
- Asperula oligantha** F.v.M. (A.
scoparia, Hook. f.)
Uromyces asperulae, McAlp.
Puccinia oliganthae, McAlp.
- Atriplex semibaccata** R. Br.
Uromyces atriplicis, McAlp.
- Avena fatua** L.
Puccinia graminis, Pers.
P. lolii avenae.
- Avena sativa** L.
Puccinia graminis, Pers.
P. lolii avenae.
- Beckmannia erucaeformis** Host.
Puccinia beckmanniae, McAlp.
P. graminis, Pers.
- Bellis perennis** L.
Puccinia distincta, McAlp.
- Beta vulgaris** L.
Uromyces betae (Pers.) Kuehn.
- Bidens pilosa** L.
Uredo bidentis, P. Henn.
- Boronia spinescens** Benth.
Puccinia boroniae, P. Henn.
- Bossiaea cinerea** R. Br.
Aecidium eburneum, McAlp.
Cronartium jacksoniae, P. Henn.
- Bossiaea heterophylla** Vent.
Aecidium eburneum, McAlp.
- Bossiaea linophylla** R. Br.
Aecidium eburneum, McAlp.
- Bossiaea microphylla** Sm.
Aecidium eburneum, McAlp.
- Bossiaea prostrata** R. Br.
Uredo bossiaee, McAlp.
- Bossiaea rhombifolia** Sieber.
Aecidium eburneum, McAlp.
- Brachycome ciliaris** Less.
Puccinia brachycomes, McAlp.
- Brachycome diversifolia** Fisch. and
Mey.
Puccinia brachycomes, McAlp.
- Brachycome pachyptera** Turcz.
Puccinia brachycomes, McAlp.
- Brachycome scapiformis** DC.
Puccinia brachycomes, McAlp.
- Briza minor** L.
Puccinia graminis, Pers.
- Bromus arenarius** Labill.
Puccinia bromina, Eriks.

- Bromus mollis** L.
Puccinia bromina, Eriks.
- Bromus racemosus** L.
Puccinia graminis, Pers.
- Bromus secalinus** L.
Puccinia graminis, Pers.
- Bromus sterilis** L.
Puccinia graminis, Pers.
- Brunonia australis** Sm.
Puccinia brunoniae, McAlp.
- Bulbine bulbosa** Haw.
Uromyces bulbinis, Thuem.
- Burchardia umbellata** R. Br.
Puccinia burchardiae, Sacc.
- Calendula officinalis** L.
Puccinia calendulae, McAlp.
- Calocephalus drummondii** Benth.
Puccinia calocephali, McAlp.
- Calocephalus lacteus** Less.
Puccinia calocephali, McAlp.
- Calotis** R. Br.
Puccinia calotidis, McAlp
- Calotis cuneifolia** R. Br.
Puccinia calotidis, McAlp.
- Caltha introloba** F.v.M.
Aecidium calthae, Grev.
- Candollea serrulata** Labill. = Stylidium graminifolium, Sw.
- Canthium** (*Plectronia*) *coprosmoides* F.v.M.
Aecidium plectroniae, Cooke.
- Carex** L.
Puccinia longispora, McAlp.
- Carex alsophila** F.v.M.
Puccinia caricis (Schum.) Reb.
- Carex breviculmis**, R. Br.
Puccinia caricis (Schum.) Reb.
- Carex caespitosa** L.
Puccinia longispora, McAlp.
- Carex gunniana** Boott.
Puccinia caricis (Schum.) Reb.
- Carex inversa** R.Br.
Puccinia caricis (Schum.) Reb.
- Carex paniculata** L.
Puccinia caricis (Schum.) Reb.
- Carex pedunculata** Muhl.
Puccinia caricis (Schum.) Reb.
- Carex vulgaris** Fr.
Puccinia longispora, McAlp.
- Carissa ovata** R.Br.
Puccinia carissae, Cke. and Mass.
- Cassia** Tourn.
Uredo pallidula, Cke. and Mass.
- Centaurea cyanus** L.
Puccinia cyani (Schleich.) Pass.
- Chiloglottis diphylla** R.Br.
Uromyces orchidearum, Cké. and Mass.
- Chiloglottis gunnii** Lindl.
Uromyces orchidearum, Cke. and Mass.
- Chrysanthemum indicum** L.
Puccinia chrysanthemi, Roze.
- Cichorium intybus** L.
Puccinia cichorii (DC.) Bell.
- Cineraria** L.
Puccinia cinerariae, McAlp.
- Clematis aristata** R.Br.
Caeoma clematidis, Thuem.
Puccinia agropyri, Ell. and Ev. I.
(*Aecidium clematidis* DC.).
- Clematis microphylla** DC.
Caeoma clematidis, Thuem.
- Coprosma billardieri** Hook.
Puccinia coprosmae, Cke.
- Coprosma hirtella** Labill.
Puccinia coprosmae, Cke.
- Correa lawrenciana** Hook.
Puccinia correae, McAlp.
- Crepis japonica** Benth.
Uredo crepidis-japonicae, Lindr.
- Cruciferae.**
Puccinia cruciferae, McAlp.
- Cryptandra hookeri** F.v.M.
= *Spyridium parvifolium*, F.v.M.
- Cymbonotus lawsonianus** Gaudich.
Aecidium cymbonoti, Thuem.
- Cynodon dactylon** Pers.
Puccinia cynodontis, Desm.
- Cyperus rotundus** L.
Puccinia cyperi, Arth.
- Dactylis glomerata** L.
Puccinia graminis, Pers.
- Dampiera alata** Lindl.
Puccinia dampierae, Syd.

- Dampiera stricta** R. Br.
Puccinia dampierae, Syd.
- Danthonia** DC.
Uromyces danthoniae, McAlp. I.
- Danthonia semiannularis** R.Br.
Uromyces danthoniae, McAlp. II., III.
- Deeringia celosioides** R.Br.
Acidium deeringiae, Cke. and Mass.
- Deyeuxia forsteri** Kunth. (*Agrostis solandri* F. v. M.)
Puccinia agrostidis, Plow.
- Deyeuxia quadriseta** Benth.
Puccinia graminis, Pers.
- Dianthus caryophyllus** L.
Uromyces caryophyllinus (Schrank) Schroet.
- Dianthus chinensis** L.
Uromyces caryophyllinus (Schrank) Schroet.
- Dichondra repens** Forst.
Puccinia dichondrae, Mont.
- Diploglottis cunninghamii** Hook. f.
Uromyces diploglottidis, Cke. and Mass.
- Distichlis maritima** Rafin.
Puccinia subnitens, Diet.
- Echinopogon ovatus** Beauv.
Puccinia graminis, Pers.
- Ehrharta stipoides** Labill. = *Micro-laena stipoides*, R.Br.
- Elymus condensatus** Presl.
Puccinia impatientis (Schw.) Arth.
- Elymus striatus** Willd.
Puccinia graminis, Pers.
- Elymus virginicus** L.
Puccinia graminis, Pers.
- Enchylaena tomentosa** R.Br.
Puccinia kochiae, Mass.
- Epilobium** Dill.
Puccinia epilobii-tetragoni (DC.) Wint.
- Epilobium billardierianum** Ser.
Puccinia epilobii-tetragoni (DC.) Wint.
- Epilobium glabellum** Forst.
Puccinia epilobii-tetragoni (DC.) Wint.
- Erechtites** Rafin.
Puccinia erechititis, McAlp.
- Erechtites arguta** DC.
Puccinia erechititis, McAlp.
- Erechtites prenanthoides** DC.
Puccinia erechititis, McAlp.
- Erechtites quadridentata** DC.
Puccinia erechititis, McAlp.
- Eriostemon myoporoides** DC.
Puccinia eriostemonis, McAlp.
- Festuca bromoides** L.
Puccinia graminis, Pers.
- Festuca ovina** L.
Puccinia festucae, Plow.
- Festuca rigida** Kunth.
Puccinia festucae, Plow.
- Geitonoplesium cymosum** A. Cunn.
Uredo geitonoplesii, McAlp.
- Geranium pilosum** Sol.
Puccinia geranii-pilosi, McAlp.
- Geum renifolium** F. v. M.
Puccinia gei, McAlp.
- Glyceria dives** F. v. M.
Puccinia graminis, Pers.
- Glyceria stricta** Hook. f.
Puccinia graminis, Pers.
- Gnaphalium japonicum** Thunb.
Puccinia gnaphalii (Speg.) P. Henn.
- Gnaphalium purpureum** L.
Puccinia gnaphalii (Speg.) P. Henn.
- Gompholobium latifolium** Sm.
Cronartium jacksoniae, P. Henn.
- Goodenia albiflora** Schlecht.
Puccinia saccardoi, Ludw.
- Goodenia geniculata** R.Br.
Puccinia saccardoi, Ludw.
- Goodenia glauca** F. v. M.
Puccinia saccardoi, Ludw.
- Goodenia hederacea** Sm.
Puccinia saccardoi, Ludw.
- Goodenia ovata** Sm.
Puccinia saccardoi, Ludw.
- Goodenia pinnatifida** Schlecht.
Puccinia saccardoi, Ludw.
- Goodia lotifolia** Salisb.
Acidium soleniiforme, Berk.
- Haemodorum** Sm.
Puccinia haemodori, P. Henn.

- Hakea** Schrad.
Uredo angiosperma, Thuem.
- Hardenbergia monophylla** Benth.
(*Kennedya monophylla* Vent.)
Uromyces hardenbergiae, McAlp.
- Helianthus annuus** L.
Puccinia helianthi, Schw.
- Helianthus tuberosus** L.
Puccinia helianthi, Schw.
- Helichrysum** Vaill.
Puccinia kalchbrenneri, De Toni.
- Hibbertia sericea** Benth.
Puccinia hibbertiae, McAlp.
- Hibiscus** L.
Puccinia heterospora, B. and C.
- Hordeum murinum** L.
Puccinia graminis, Pers.
- Hordeum secalinum** Schreb.
Puccinia graminis, Pers.
- Hordeum vulgare** L.
Puccinia graminis, Pers.
P. simplex (Koern.) Eriks. and Henn.
- Hypericum japonicum** Thunb.
Melampsora hypericorum (DC.)
Senroet.
Aecidium disseminatum, Berk.
- Hypochoeris glabra** L.
Puccinia hypochoeridis, Oud.
- Hypochoeris radicata** L.
Puccinia hypochoeridis, Oud.
- Hypoxis glabella** R. Br.
Puccinia hypoxidis, McAlp.
- Jacksonia scoparia** R. Br.
Cronartium jacksoniae, P. Henn.
- Juncus effusus** L.
Puccinia juncophila, Cke and Mass.
- Juncus maritimus** Lam.
Puccinia juncophila, Cke and Mass.
- Juncus pallidus** R. Br.
Puccinia juncophila, Cke and Mass.
- Juncus pauciflora** R. Br.
Puccinia juncophila, Cke and Mass.
- Kennedya monophylla**, Vent. = *Hardenbergia monophylla*, Benth.
- Kochia sedifolia** F. v. M.
Puccinia kochiae, Mass.
- Kochia villosa** Lindl.
Puccinia kochiae, Mass.
- Lactuca** L.
Puccinia prenanthis (Pers.) Lindr.
- Lagenophora billardieri** Cass.
Puccinia lagenophorae, Cke.
- Lagenophora huegelii** Benth.
Puccinia lagenophorae, Cke.
- Lavatera plebeia** Sims.
Puccinia malvacearum, Mont.
- Leschenaultia linarioides** DC.
Puccinia gilgiana, P. Henn.
- Limnanthemum indicum** Thw.
Aecidium nymphoidis, DC.
- Limosella aquatica** L.
Uromyces limosellae, Ludw.
- Linum marginale** A. Cunn.
Melampsora lini (Pers.) Tul.
- Linum usitatissimum** L.
Melampsora lini (Pers.) Tul.
- Lobelia anceps** L.
Puccinia aucta, Berk. and F. v. M.
- Lobelia pratioides** Benth.
Puccinia aucta, Berk. and F. v. M.
- Lobelia purpurascens** R. Br.
Puccinia aucta, Berk. and F. v. M.
- Lolium perenne** L.
Puccinia lolii, Niels.
- Loranthus celastroides** Sieber.
Puccinia loranthicola, McAlp.
- Luzula campestris** DC.
Puccinia tenuispora, McAlp.
- Luzula oldfieldii** Hook. f.
Puccinia tenuispora, McAlp.
- Malva rotundifolia** L.
Puccinia malvacearum, Mont.
- Malva sylvestris** L.
Puccinia malvacearum, Mont.
- Mentha laxiflora** Benth.
Puccinia menthae, Pers.
- Mentha pulegium** L.
Puccinia menthae, Pers.
- Microtis porrifolia** R. Br.
Uromyces microtidis, Cke.
- Microlaena stipoides** R. Br. (*Ehrharta stipoides* Labill.)
Uromyces ehrhartaе, McAlp.
- Muehlenbeckia adpressa** Meissn.
Puccinia muehlenbeckiae (Cke.) Syd.
- Muehlenbeckia cunninghami** F. v. M.
Uromyces politus (B. and Br.) McAlp.

- Muehlenbeckia gracillima** Meissn.
Puccinia muehlenbeckiae (Cke.) Syd.
- Olearia argophylla** F. v. M. (*Aster*).
Puccinia oleariae, McAlp.
- Olearia axillaris** F. v. M.
Aecidium oleariae, McAlp.
- Opercularia aspera** Gaertn.
Puccinia operculariae (Morr.) Syd.
- Opercularia varia** Hook. f.
Puccinia operculariae (Morr.) Syd.
- Pelargonium australe** Jacq.
Puccinia morrisoni, McAlp.
- Phalaris canariensis** L.
Puccinia graminis, Pers.
- Phalaris minor** Retz.
Puccinia graminis, Pers.
- Phragmites communis** Trin.
Puccinia magnusiana, Koern.
P. tepperi, Ludw.
- Plagianthus sidoides** Hook.
Puccinia plagianthi, McAlp.
- Plagianthus spicatus** Benth.
Puccinia malvacearum, Mont.
- Plantago varia** R. Br.
Aecidium plantaginis-variae, McAlp.
- Platylobium formosum** Sm.
Aecidium platylobii, McAlp.
Cronartium jacksoniae, P. Henn.
- Electronia coprosmoides** = *Canthium*
coprosmoides, F. v. M.
- Poa annua** L.
Puccinia poarum, Niels.
- Poa caespitosa** Forst.
Puccinia poarum, Niels.
- Poa pratensis** L.
Puccinia poarum, Niels.
- Podolepis longipedata** A. Cunn.
Puccinia podolepidis, McAlp.
- Polygonum aviculare** L.
Uromyces polygoni, Fekl.
- Pomaderris apetala** Labill.
Uredo spyridii, Cke. and Mass.
- Pratia erecta** Gaudich.
Puccinia aucta, Berk. and F. v. M.
- Pratia pedunculata** Benth.
Puccinia aucta, Berk. and F. v. M.
- Pratia platycalyx** Benth.
Puccinia aucta, Berk. and F. v. M.
- Prunus amygdalus** Stokes.
Puccinia pruni, Pers.
- Prunus armeniaca** L.
Puccinia pruni, Pers.
- Prunus domestica** L.
Puccinia pruni, Pers.
- Prunus persica** Stokes.
Puccinia pruni, Pers.
- Ranunculus** L.
Aecidium ranunculacearum, DC.
- Ranunculus gunnianus** Hook.
Aecidium ranunculacearum, DC.
- Ranunculus lappaceus** Sm.
Aecidium ranunculacearum, DC.
- Ranunculus parviflorus** L.
Aecidium ranunculacearum, DC.
- Ranunculus rivularis** Banks and Sol.
Aecidium ranunculacearum, DC.
- Rhagodia billardieri** R. Br.
Uredo rhagodiae, Cke. and Mass.
- Rosa canina** L.
Phragmidium subcorticium (Schränk)
Wint.
- Rosa laxa** Retz.
Phragmidium subcorticium (Schränk)
Wint.
- Rosa rubiginosa** L.
Phragmidium subcorticium (Schränk)
Wint.
- Rottboellia compressa** L.
Puccinia cacao, McAlp.
- Rubus moluccanus** L.
Phragmidium longissimum, Thuem.
- Rubus parvifolius** L.
Phragmidium barnardi, Plow. and
Wint.
- Ruellia australis** Cav.
Puccinia mussoni, McAlp.
- Rumex brownii** Campd.
Puccinia ludwigii, Tepp.

- Rumex flexuosus** Sol.
Puccinia ludwigii, Tepp.
- Saccharum officinarum** L.
Uredo kuehnii, Krueg.
- Scaevola** L.
Uromyces puccinioides, Berk. and F. v. M.
- Schelhammera undulata** R. Br.
Uredo schelhammerae, McAlp.
- Scirpus nodosus** Rottb.
Uredo scirpi-nodosi, McAlp.
- Scleranthus diander** R. Br.
Uromyces scleranthi, Rostr.
- Scorzonera angustifolia** L.
Puccinia angustifoliae, McAlp.
- Secale cereale** L.
Puccinia graminis, Pers.
- Selliera radicans** Cav.
Uromyces puccinioides, Berk. and F. v. M.
- Senecio brachyglossus** F. v. M.
Puccinia tasmanica, Diet.
- Senecio pectinatus** DC.
Puccinia tasmanica, Diet.
- Senecio velleioides** A. Cunn.
Puccinia tasmanica, Diet.
- Senecio vulgaris** L.
Puccinia tasmanica, Diet.
- Sorghum halepense** Pers.
Puccinia purpurea, Cke.
- Sorghum vulgare** Pers.
Puccinia purpurea, Cke.
- Sporobolus indicus** R. Br.
Uromyces tenuiculis, McAlp.
- Spyridium parvifolium** F. v. M.
(*Cryptandra hookeri* F. v. M.)
Uredo spyridii, Cke and Mass.
- Stellaria media** Cyrill.
Puccinia arenariae (Schum.) Schroet.
- Stipa flavescens** Labill.
Puccinia flavescens, McAlp.
- Stipa semibarbata** R. Br.
Puccinia flavescens, McAlp.
- Stylidium graminifolium** Sm. (*Candollea serrulata* Labill.)
Puccinia stylidii, McAlp.
- Tabernaemontana orientalis** R. Br.
Caeoma apocyni, McAlp.
- Tetragonia implexicoma** Hook. f.
Puccinia tetragoniae, McAlp.
- Thelymitra antennifera** Hook. f.
Uromyces thelymitrae, McAlp.
- Thelymitra flexuosa** Endl.
Uromyces thelymitrae, McAlp.
- Threlkeldia drupata** Diels.
Puccinia dielsiana, P. Henn.
- Tillaea sieberiana** Schult.
Uredo tillaeae, McAlp.
- Tremandra stelligera** R. Br.
Puccinia pritzeliana, P. Henn.
- Tricoryne elatior** R. Br.
Uromyces tricorynes, McAlp.
- Trifolium repens** L.
Uromyces trifolii (Alb. and Schw.) Winter.
- Triticum polonicum** L.
Puccinia graminis, Pers.
P. triticina, Eriks.
- Triticum vulgare** Vill.
Puccinia graminis, Pers.
P. triticina, Eriks.
- Urtica dioica** L.
Puccinia caricis (Schum.) Reb. I.
(*Aecidium urticae* Schum.)
- Velleia macrocalyx** De Vriese.
Puccinia saccardoi, Ludw.
- Velleia paradoxa** R. Br.
Puccinia saccardoi, Ludw.
- Veronica** L.
Aecidium veronicae, Berk.
- Veronica calycina** R. Br.
Aecidium disciforme, McAlp.
- Veronica gracilis** R. Br.
Aecidium disciforme, McAlp.
- Vicia faba** L.
Uromyces fabae (Pers.) De Bary.
- Vigna catjang** Walp.
Uromyces appendiculatus (Pers.) Link.
- Viola betonicifolia** Sm.
Puccinia hederaceae, McAlp.

Viola hederacea Labill.

Puccinia hederaceae, McAlp.

Vittadinia australis Rich.

Puccinia vittadiniae, McAlp.

Wurmbea dioica F. v. M.

Puccinia wurmbeae, Cke. and Mass.

Uredo anguillariae, Cooke.

Xanthosia pusilla Bunge.

Puccinia xanthosiae, McAlp.

Zea mays L.

Puccinia maydis, Bereng.

Zornia diphylla Pers.

Puccinia zorniae (Diet.) McAlp.

Zygophyllum billardieri DC.

Uromyces vesiculosus, Wint.

Zygophyllum glaucescens F. v. M.

Uromyces vesiculosus, Wint.

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